Crisil Intelligence

Industry assessment

Powertrain Solutions and Alloys & Metallics Components

Hero Motors Ltd | **June 2025**

by S&P Global

Crisil Intelligence

Contents

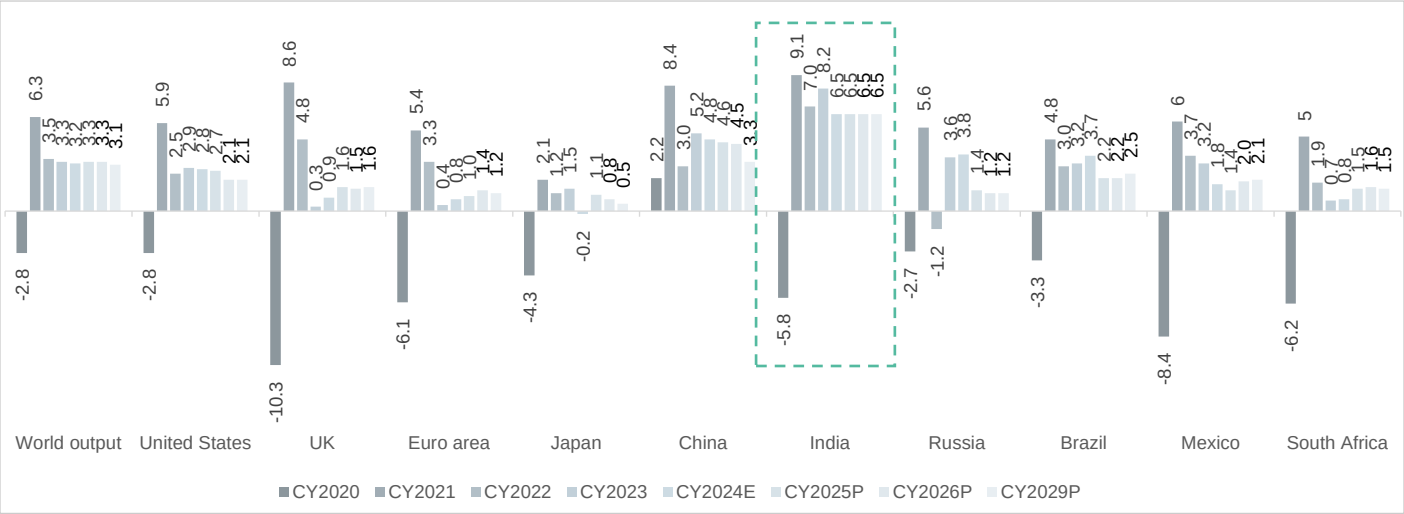
Please Note: Year to be read as calendar year wherever the reference of year is given without fiscal / FY / financial year.

1. Macroeconomic overview of global and Indian economy

Overview of global economy

Global economic growth remained steady during CY2024 with several large economies showing resilience despite geopolitical tensions, high interest rates and the growing intensity of extreme weather events. Further tightening of financial conditions has also challenged the global trade and industrial production in CY2024. Given continued inflationary pressure, central banks in both advanced emerging markets and developing economies remained cautious in easing monetary policy. The global outlook remains subdued, both advanced economies and emerging market and developing economies are set to grow upward marginally in CY2024, reflecting upgrade for Asian countries mainly China and India. India has witnessed strong growth momentum despite these geopolitical tensions and uncertainties in the global economic environment. A major push to economic growth has been fueled by investments and key sectors such as information technology, services, agriculture, and manufacturing.

Nominal GDP growth of key economies



Note: On Calendar Year (CY) basis

** Euro area comprises 19 member countries of the EU*

Source: International Monetary Fund (IMF); World Economic Outlook (WEO) – January 2025 update, Crisil Intelligence

As per the International Monetary Fund's (IMF) World Economic Outlook:

- The global GDP growth is estimated at 3.2% in CY2024 and is projected to be at 3.3% in CY2025 and CY2026 due to the upgrades for China, the United States (US), large emerging markets and developing economies.The forecast for CY2025 broadly remains unchanged from the previous estimates in October 2024, majorly on account of an upward revision in the United States offsetting downward revision in other economies. However, the GDP growth forecast remains below the historical (CY2000-2019) annual average of 3.7% with elevated central bank policy rates to fight inflation, a withdrawal of fiscal support by major economies amid high debt weighing on economic activity and low underlying productivity growth.
- In the case of advanced economies which include the US, Japan and Euro area, growth forecast is relatively stable at 1.7% for both CY2023 and CY2024. Recovering real income are expected to support the cyclical

recovery in consumption in spite of the fact that trade headwinds including sharp uptick in trade policy uncertainty are expected to keep investment subdued.

- The United States witnessed robust growth in basic demand due to strong wealth effects, a less restrictive monetary policy stance and supportive financial conditions. However Growth is expected to decline 2.1% in CY2026 compared to projected growth of 2.7% in CY2025.
- In the Euro area growth is expected to pick up in CY2024 due to better export performance of goods. However, persistent slowdown in manufacturing put pressure on growth of countries such as Germany and Italy. Though, Italy's domestic demand is expected to benefit from European Union-financed National Recovery and Resilience Plan, Germany is experiencing strain from fiscal consolidation and sharp decline in real estate. Weaker than expected momentum at the end of CY2024 owing to manufacturing slowdown, geopolitical tensions and policy uncertainty will reflect downward revision by 0.2% to 1.0 % in CY2025.Growth is expected to rise to 1.4% supported by stronger domestic demand, as financial condition ease and uncertainty will retract up to certain extent.
- In Japan growth is expected to decline in CY2024 majorly due to temporary supply disruptions linked to the shutdown of major automobile plant and fading of one-off factors that boosted activity in CY2023 such as surge in tourism. The output contracted moderately in Japan owing to temporary supply disruption. Growth is projected to slow from an estimated 1.5% in CY2023 to -0.2% in CY2024. As per latest data revisions. an acceleration to 1.1% is predicted in CY2025, with expected boost by private consumption as real wage growth strengthens. However further decline in growth expected to 0.8 in CY2026.In contrast, economic recovery shape up in Europe majorly due to falling inflation and interest rates encouraged domestic demand.
- The growth rate in emerging market and developing economies which include China, India, Russia, Brazil, Mexico, and South Africa is expected to remain at 4.2% in CY2024 declined from 4.4% in CY2023, with a slowdown more than expected in emerging and developing Asian countries such as India and China's growth, offset mainly by rising growth for economies in Middle East, Central Asia and Sub-Saharan Africa. In India growth is projected to be strong at 6.5% in CY2025 and CY2026 which is in line with IMF previous estimates .China growth is marginally revised upward by 0.1% to 4.6% in CY2025 due to carryover from CY2024 and is further expected to remain stable at 4.5% in CY2026, as the effect of trade policy uncertainty dissipate and decline in the labour supply. Emerging and developing economies are expected to experience stable growth at 4.2% through CY2024 and CY2025 albeit with some regional differences.

Overview of the Indian economy

Review of GDP growth over fiscals 2019-2024 and Outlook for fiscals 2025-2030

India's GDP exceeded expectations during all four quarters of fiscal 2024. However, growth slowed down in fourth quarter but stayed strong. According to the National Statistics Office's (NSO) second advance estimates in February 2025, GDP growth was revised higher 100 bps to 9.2% for fiscal 2024 and 60 bps up to 7.6% for fiscal 2023.

Growth surpassed forecasts in the fiscal 2024, driven by strong government spending and a sharp rise in manufacturing and construction growth. Globally, growth in major economies such as the US and China beat estimates and has contributed to better export earnings for India.

According to the National statistics Offices (NSO) second advance estimates (SAE) based on the data for three quarters for the fiscal 2025, India's real gross domestic product (GDP) growth is at 6.5%, significantly slower than the 9.2% in fiscal 2024. Weak investments amid reduced government capital expenditure (capex) are the primary reason for the deceleration. However, private consumption is expected to rise significantly compared to fiscal 2024's weak performance.

Based on NSO (SAE), third-quarter of fiscal 2025, GDP growth improved to 6.2% year-on-year from 5.6% in previous quarter.

Crisil Intelligence expects GDP growth to moderate to 6.5% in fiscal 2025 owing to slowing demand, particularly in United States and China, will weigh on global growth. Geopolitical tensions, remain a risk for trade flows and supply chain pressures for industry and along with the impact of high interest rates.

Drivers for India's economic growth

- Strong domestic demand is expected to drive India's growth over peer economies in the medium term.
- Investment prospects are optimistic, given the government's capex push, progress of the Production Linked Incentive (PLI) scheme, healthier corporate balance sheets, and a well-capitalised banking sector with low non-performing assets.
- The government's future capex is expected to be supported by tax buoyancy, simplified tax structures with lower rates, reassessment of the tariff structures and digitalisation of the tax filing process.
- Medium-term growth is anticipated to be bolstered by increased capital spending on infrastructure and asset development projects, thereby translating into enhanced growth multipliers.

Key factors in budget 2025-26 that can influence medium to long term growth:

- Stronger Consumption Support: Tax relief measures and enhanced allocations for welfare programs like PMAY, PMGSY and MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Scheme) to boost demand and economic activity.
- Sustained Infrastructure Investment: Increased funding for roads, highways, railways, and urban development, driving long-term growth and job creation.
- Government-Led Capital Expenditure: Continued high Capex allocation supporting various industries.
- Employment & Skilling Initiatives: Allocations for new employee generation schemes, vocational training, and opening of 'centres of excellence' will enhance workforce productivity and helps in skilling the youth of the country.
- Push for Innovation & Industrial Growth: Increased R&D funding, incentives for EVs and electronics manufacturing, and export promotion to strengthen India's global competitiveness.
- On consumption front, recently there was a key announcement made during union budget 2025-26 in February 2025 pertaining to direct taxes. As per new tax regime ,no income tax payable up to annual income of Rs 12.75lakh and a new tax bracket subject to 25% tax added to 20-24Lakh income tax slab.

2. Review and outlook of the global auto industry

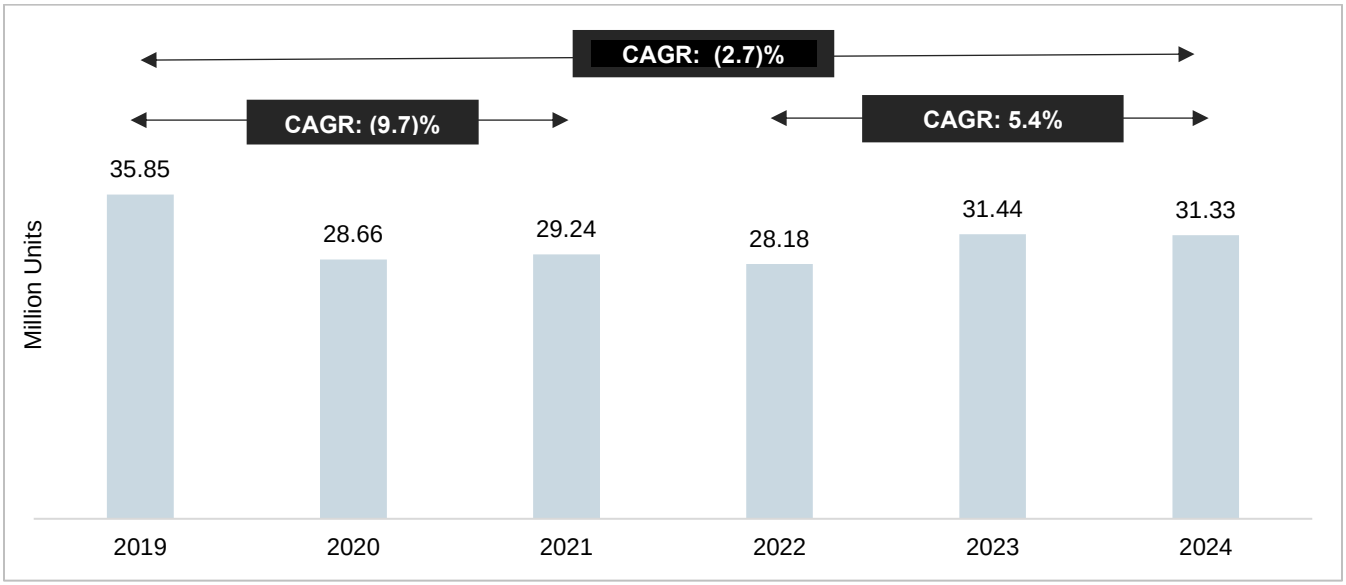
Global passenger vehicle industry

Review of the global passenger vehicles industry (2019 to 2024)

Overall, the global passenger cars industry has undoubtedly undergone a period of significant transformation from 2019 to 2024. The pandemic's impact was undeniable, but the industry has demonstrated resilience and is adapting to a new reality. As the market recovers, electrification and advancements in autonomous driving technologies are poised to become the driving forces shaping the future of the passenger cars industry. This is not just a recovery; it's a shift in gears towards a more sustainable and technologically advanced automotive landscape. The road ahead remains riddled with uncertainties, but the industry is positioned to navigate them with a renewed focus on innovation, resilience and commitment to a cleaner future.

Historic production development (2019-2024)

Review of global PV sales volumes

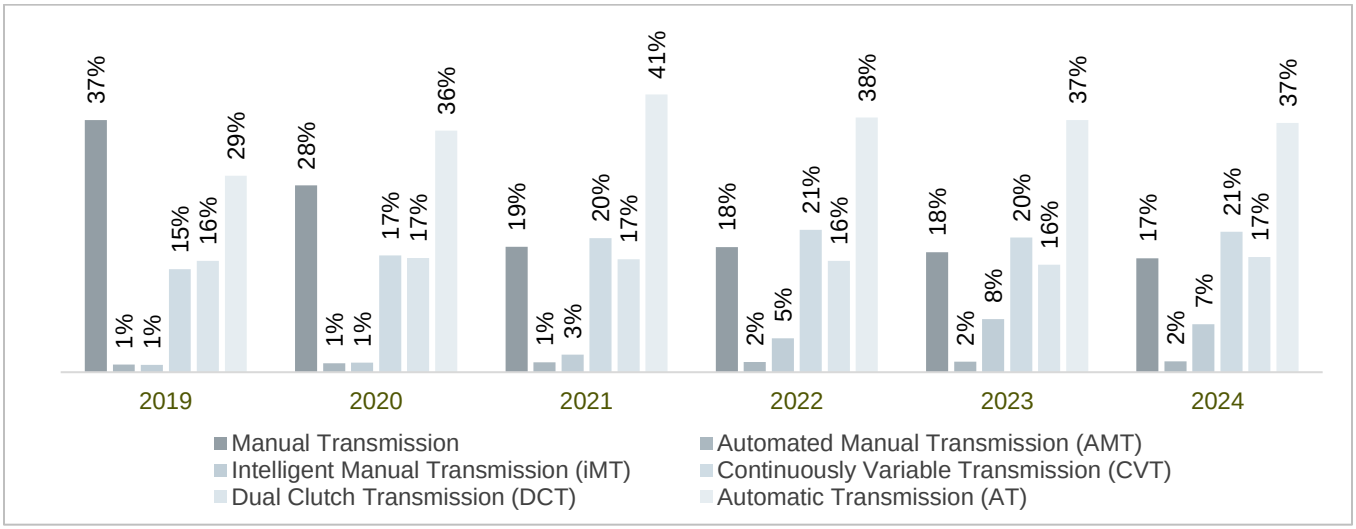


Note: Above figures comprise of sales for United States, Europe, and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

Passenger car sales boomed globally in 2019, then plummeted during the pandemic (2020-2021). A tentative recovery began in 2022-2023 as the markets started opening up gradually after the pandemic abated. Between 2019 and 2021, the global passenger vehicles industry logged a CAGR of (9.7)%. Further, between 2022 and 2024, the industry clocked a CAGR of 5.4% with volumes reaching up to 31.33 million units. Between 2019 to 2024, the industry logged a CAGR of (2.7)% on account of a mix of major downturns and gradual upticks.

Review of global PV sales volumes based on transmission type (% wise share)



Note: Above figures comprise sales for US, Europe and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

Automatic transmission has witnessed a significant uptick, escalating from contributing 29% in 2019 to 37% in 2024. This surge is attributed to worsening traffic conditions, increasing affordability and growing consumer preference for comfort. Notably, in the premium segment, there is a discernible shift towards smoother driving experiences, fuelling the demand for automatic transmission, continuously variable transmission (CVT) and dual clutch transmission (DCT) technologies.

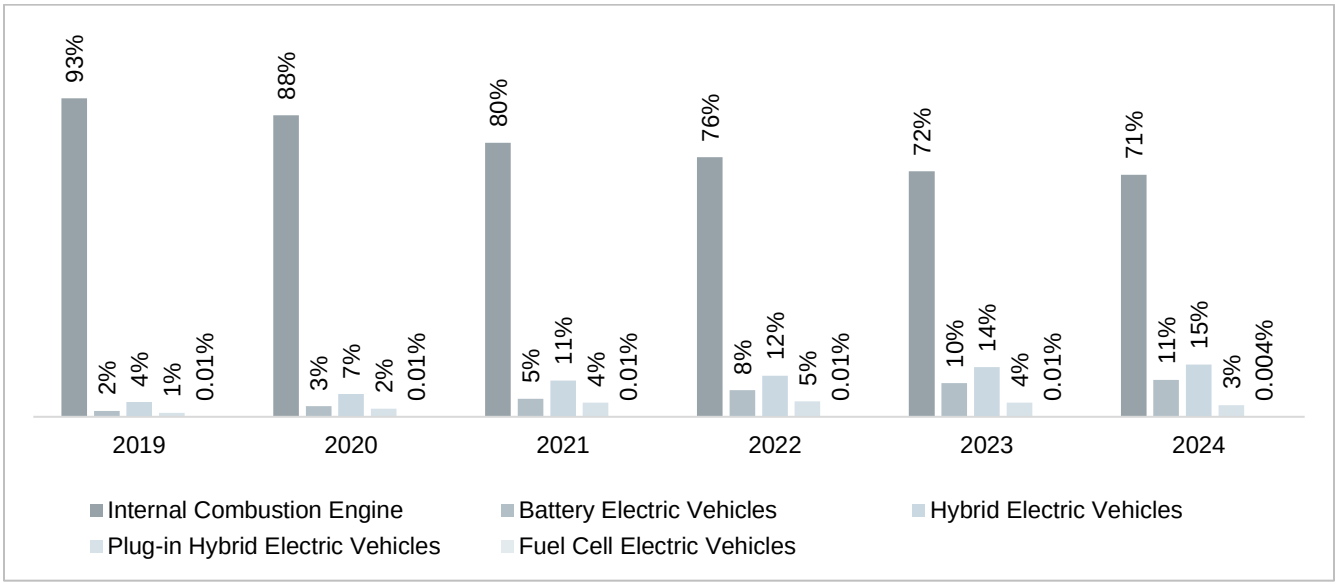
For decades, manual transmission reigned supreme, particularly in markets where fuel efficiency was paramount. Its simple design and direct connection between the driver and engine offered exceptional control and minimised energy loss. However, several factors have led to a change in this scenario.

The rise of urbanisation: The constant stop-and-go driving of urban environments is far less suited to the constant clutch modulation and gear changes required by manual transmission. Automatic transmission with its seamless operation offers a far more comfortable and less stressful driving experience in these conditions.

The comfort factor: Consumer preferences are tilting towards convenience and a smoother driving experience. The ease of use and minimal driver intervention offered by automatic transmission is increasingly valued, especially by a growing demographic of older drivers who may find the physical demands of manual transmission less appealing.

Technological advancements: Automatic transmissions have not remained stagnant. Advancements in technology have led to significant improvements in their fuel efficiency, making them a more viable option for eco-conscious drivers. Additionally, the development of new automatic transmission types, such as CVT and DCT, offers a wider range of driving experiences, catering to both comfort-seeking individuals and performance enthusiasts. CVTs, due to their focus on fuel efficiency, smooth driving experience, and ease of operation, that aligns well with the needs of many car buyers, have gained considerable momentum over the years. Its overall share increased from 15% in 2019 to 21% in 2024, marking its strong existence amongst the other transmission counterparts.

Review of global PV sales volumes based on powertrain type (% wise share)

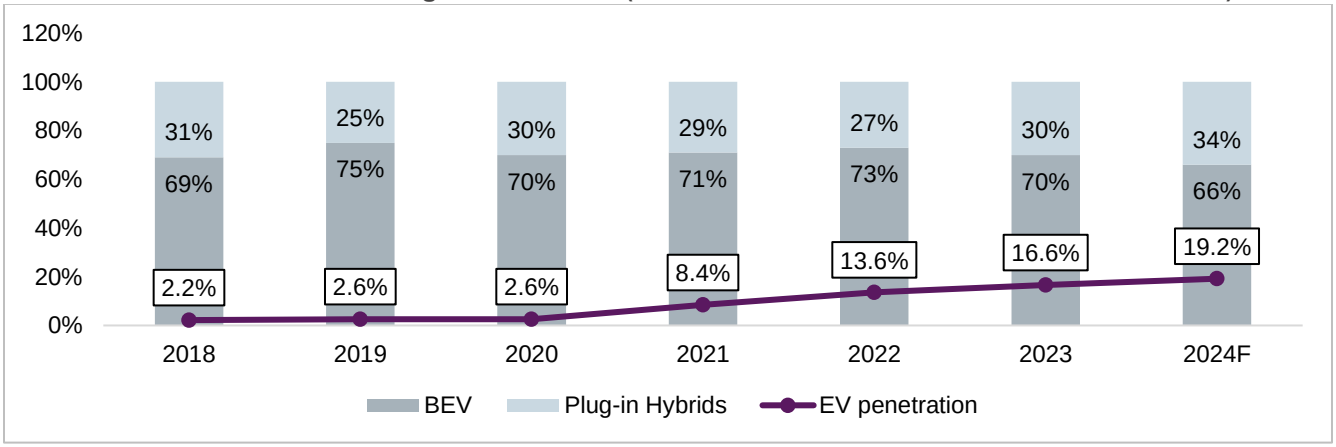


Note: The above figures comprise sales for United States, Europe and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

The electric revolution

Review of electrification trend in global PV sales (BEVs dominance in the electric alternatives lot)



Note: EV penetration is the percentage of overall sales. Also, EV penetration is inclusive of passenger cars and LCVs

Source: EV-volumes.com, CRISIL Intelligence

Battery electric vehicles (BEVs) emerged as the vanguard of the electric revolution. Their zero-tailpipe emissions and silent operation offered a compelling alternative to polluting ICE vehicles. Governments around the world started offering subsidies and incentives for BEV purchases, further accelerating their adoption. This spurred significant investments from car manufacturers in research and development, leading to advancements in battery technology, range improvement and charging infrastructure development. While initial concerns about driving range and charging availability remain hurdles, the industry is actively addressing them through advancements in battery density and the expansion of charging networks. Major car manufacturers are now dedicating a significant portion of their resources to BEV development, recognising their potential as the future of personal transportation.

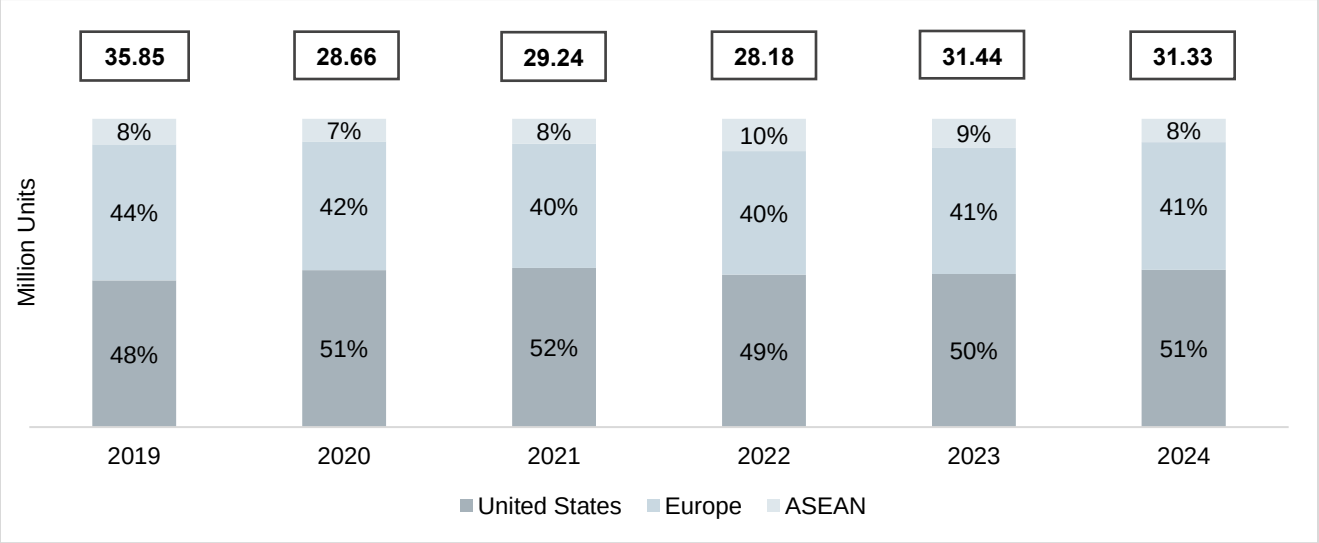
Hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs) offer a bridge between the familiar ICE technology and the future of electric mobility. HEVs combine an electric motor with a gasoline engine, allowing for electric-only driving at low speeds and utilising the gasoline engine for longer journeys. PHEVs operate similarly but boast of larger battery packs that can be charged from an external source, enabling an extended electric-only driving range as compared to HEVs. These hybrid options cater to consumers who are hesitant to fully commit to BEVs due to range anxiety but still desire the environmental benefits of electric propulsion. The industry is constantly refining hybrid technology, focusing on improving electric range and reducing dependence on gasoline engines.

Fuel cell electric vehicles (FCEVs) present a long-term vision for clean transportation. They use hydrogen fuel cells to generate electricity, emitting only water vapour. While FCEVs boast of extended range and rapid refuelling times similar to ICE vehicles, their widespread adoption faces significant challenges. The lack of widespread hydrogen refuelling infrastructure and the high cost of FCEV technology are major hurdles. Nevertheless, the industry continues research and development efforts to bring down costs and build hydrogen infrastructure, recognising FCEVs' potential for long-distance travel and heavy-duty applications.

The future of passenger car powertrains is unlikely to be dominated by a single technology. Instead, a multi-pronged approach catering to diverse needs and regional priorities is expected.

Global passenger car sales by geography type

Review of global PV sales volume share by geography type

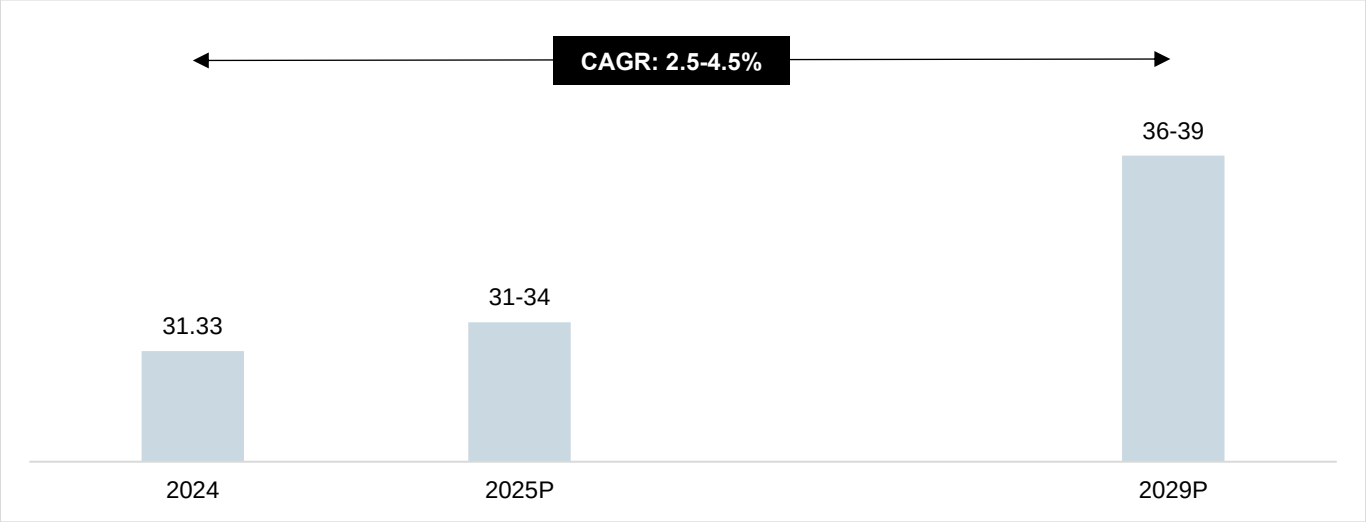


Source: Mordor Intelligence, CRISIL Intelligence

The narrative of global passenger car sales from 2019 to 2024 unfolds differently depending on the region. However, a common thread across all regions is the anticipated surge in EV adoption. Government incentives and growing environmental concerns are likely to accelerate EV sales, shaping the future of the global passenger car market. While the pace of this shift might vary by region, EVs are expected to be a dominant force in the years to come.

Outlook of global passenger vehicles industry (2024 to 2029)

Outlook of overall global PV sales volume



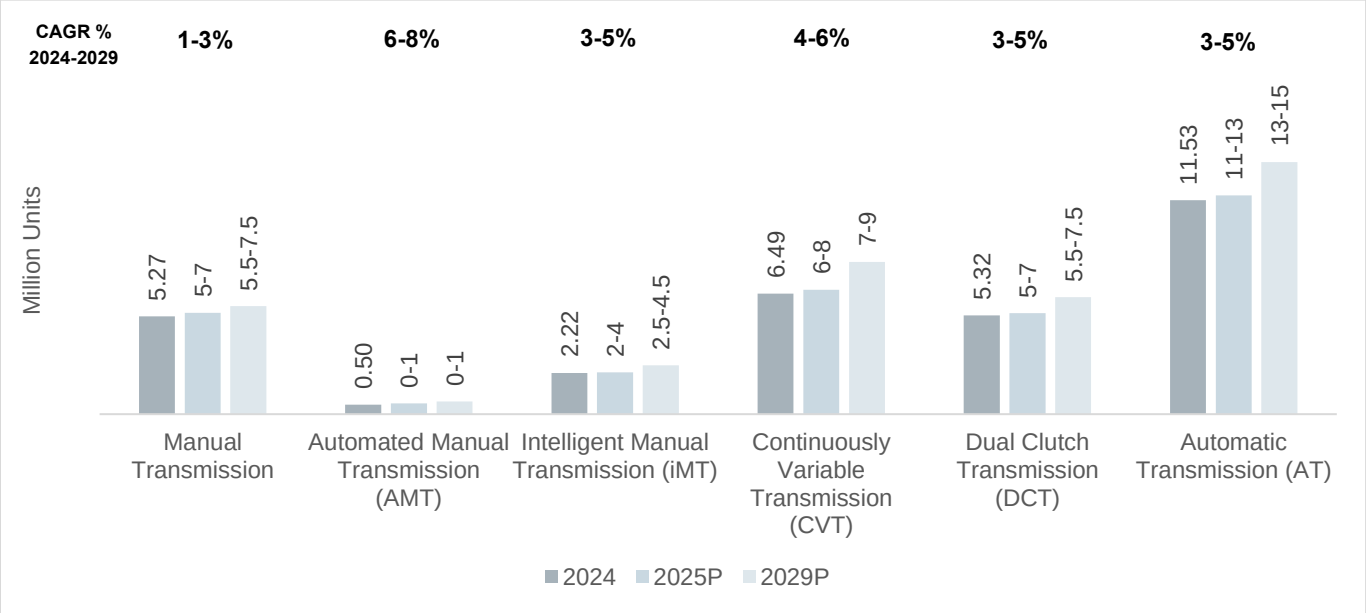
Note: Figures above include sales for the United States, Europe, and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

The global passenger car market is expected to experience moderate growth from 2024 to 2029 at a slower pace than before the pandemic. This can be attributed to factors such as global economic uncertainty and ongoing supply chain issues. In addition, shifting consumer preferences towards electric vehicles and alternative ownership models could put a dent in traditional car sales. However, rising demand in emerging markets, advancement in EV technology, and government incentives promoting clean transportation could counter these trends. The future of the passenger car market hinges on a complex interplay of these forces.

On an overall level, global PV market is expected to witness a CAGR of 2.5-4.5% between 2024-2029 with volumes reaching up to 36-39 million units in 2029.

Outlook of overall global PV sales volume by transmission type



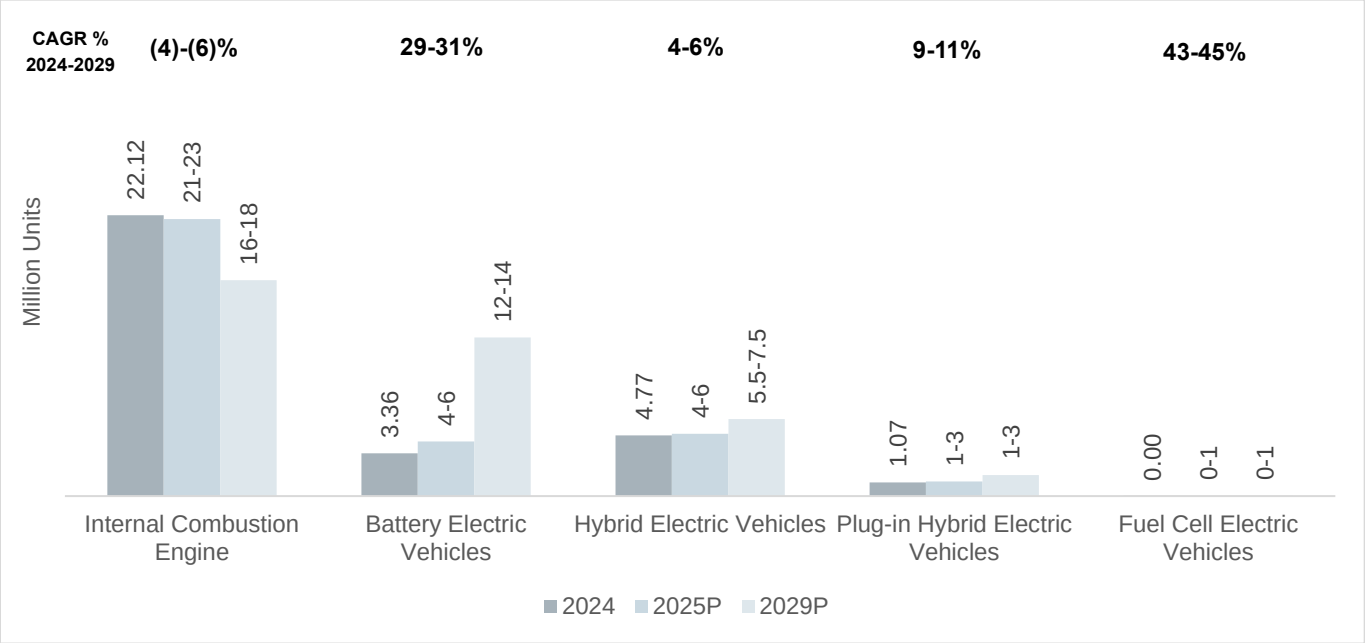
Note: Figures above include sales for the United States, Europe, and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

The global passenger car market by transmission type is poised for a shift between 2024 and 2029. Automatic transmissions, particularly torque converters, are expected to hold strong due to their comfort. ATs are expected to witness a CAGR of 3-5% between 2024-2029 and reach 13-15 million units by 2029.

Manual transmissions are expected to increase by a modest 1-3% between 2024-2029, as consumers prioritise comfort and advancement make automatics more fuel-efficient. Continuously variable transmissions (CVTs) are expected to rise significantly in popularity for their smooth and potentially fuel-efficient driving experience along with seamless acceleration. In addition, in the wake of growing concerns regarding climate change and fuel consumption, there is an increasing emphasis on enhancing fuel efficiency in vehicles. CVT enables optimized engine performance, achieving higher fuel efficiency and reduced carbon footprint. Dual-clutch transmissions (DCTs) on the other hand might see a niche increase in performance cars. The biggest change is expected to be the rise of electric vehicles, which will reduce the need for traditional transmissions altogether. This presents a strategic advantage for DCT technology, positioning it favorably for substantial penetration growth in the passenger vehicle segment in the forthcoming years.

Outlook of overall global PV sales volume by powertrain type



Note: Figures above include sales for the United States, Europe, and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

The global passenger car market by powertrain type is poised for a dramatic shift between 2024 and 2029. ICE vehicles, which were a significant player initially, will face increasing pressure from cleaner alternatives, particularly BEVs. BEVs are expected to log a CAGR of 29-31% to reach approximately 12-14 million units by 2029. Rising fuel costs, stricter emission regulations, and advancement in battery technology will incentivise consumers to move towards BEVs. Government support for BEVs and investment in charging infrastructure will further accelerate this transition.

Hybrid electric vehicles (HEVs) are expected to maintain a steady presence, offering a middle ground for those hesitant to fully commit to BEVs due to charging limitations thus clocking a CAGR of 4-6% between 2024-2029. However, PHEVs and FCEVs are likely to remain niche players due to charging infrastructure limitations (PHEVs) and the high cost and limited refuelling stations (FCEVs). The future of car powertrains will be a fascinating interplay of adaptation and innovation, with BEVs leading the charge towards a cleaner and more sustainable transportation landscape.

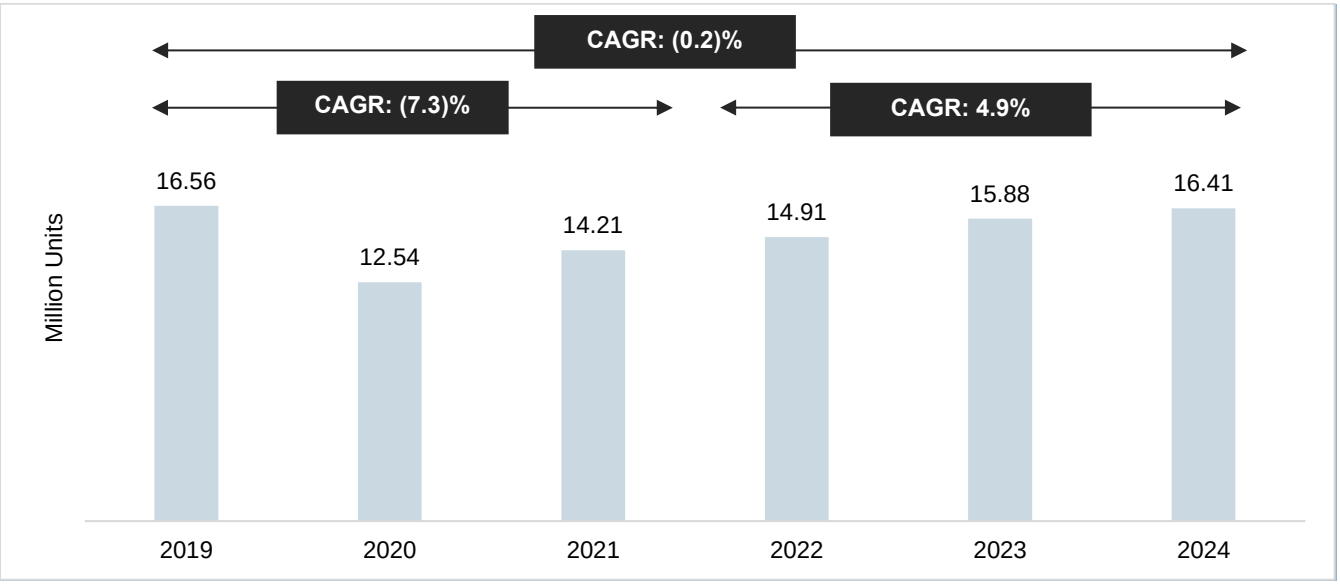
Global two-wheeler industry

Review of global two-wheeler industry (2019 to 2024)

The global two-wheeler industry underwent major transformation over 2019-2023. A confluence of factors fuelled tremendous growth, while unforeseen challenges reshaped the landscape. Urbanisation, particularly in developing economies, created a surge in demand for affordable and efficient transportation. According to the United Nations (UN) Department of Economics and Social Affairs, nearly 68% of the world's population will live in urban areas by 2050. Two-wheelers, with their manoeuvrability and fuel efficiency, have emerged as the perfect solution for navigating congested city streets. Furthermore, the rise of a strong middle class with increased disposable income fuelled the desire for personal mobility, propelling two-wheeler sales.

Historic production development (2019-2024)

Review of global two-wheeler sales volume



Note: Above figures comprise sales in the US, Europe and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

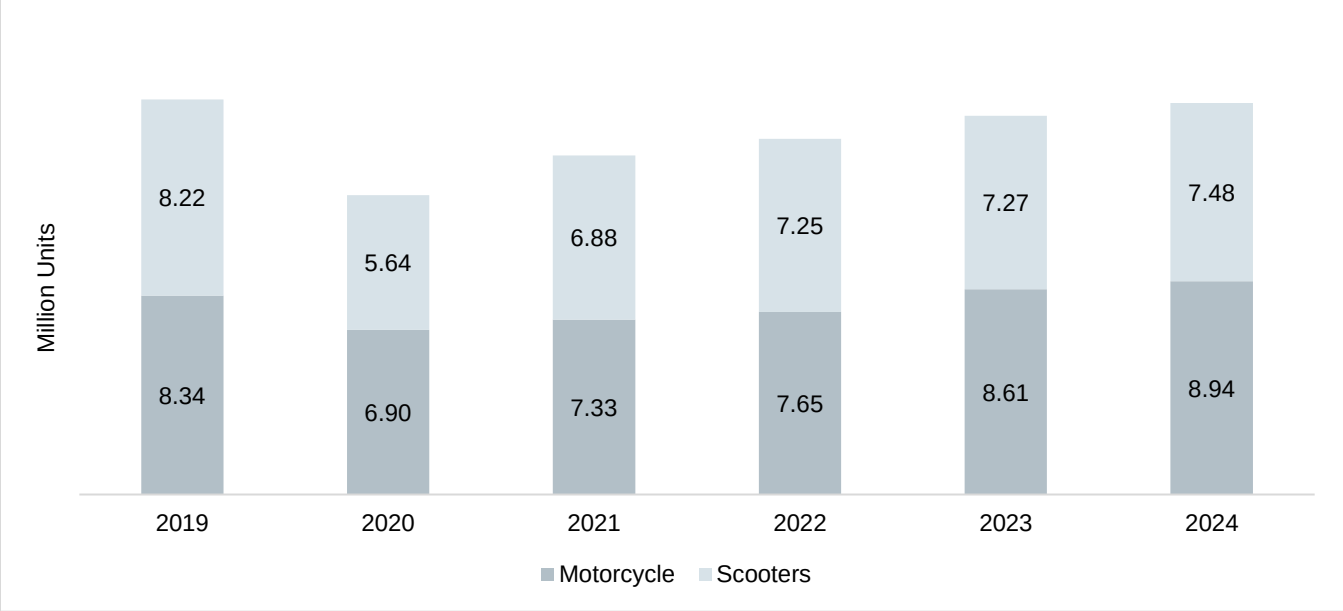
Over 2019-2024, developing economies, particularly Southeast Asia, led the charge in the two-wheeler market with a surge in sales fuelled by affordability, a growing middle class and rapid urbanisation.

Globally, consumer preferences shifted to fuel-efficient options such as scooters and smaller motorcycles. User-friendly automatic scooters also gained popularity, especially in congested cities. The emergence of electric two-wheelers has offered an exciting eco-friendly alternative with potentially lower running costs. Economic downturns impacted sales globally, while stricter emission regulations posed challenges for manufacturers, particularly those in developing regions. Safety concerns remained a major hurdle, especially where traffic infrastructure lagged.

Between 2019 and 2021, the industry witnessed a CAGR of (7.3)% due to the pandemic as demand from all the geographies were hit. Demand revived at a CAGR of 4.9% between 2022 and 2024, with sales touching 16.41 million

units in 2024. Overall, between 2019 and 2024, the industry witnessed a CAGR of (0.2)%, with volumes in 2024 still not reaching the pre-pandemic number of 16.56 million units.

Review of global two-wheeler sales volume by vehicle segmentation



Note: Above figures comprise of sales for the US, Europe and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

The global two-wheeler market, comprising motorcycles and scooters, witnessed a period of contrasting fortunes between 2019 and 2024. Developed economies have seen a slowdown, particularly for larger engine motorcycles. Rising fuel prices and a growing focus on fuel efficiency are the likely culprits. However, in developing economies, a surge in disposable income has fuelled the demand for higher cc motorcycles, catering to a desire for touring and recreational riding. The motorcycle industry witnessed a CAGR of (6.2)% between 2019 and 2021, CAGR of 8% between 2022 and 2024, and an overall growth of 1.4% between 2019 and 2024.

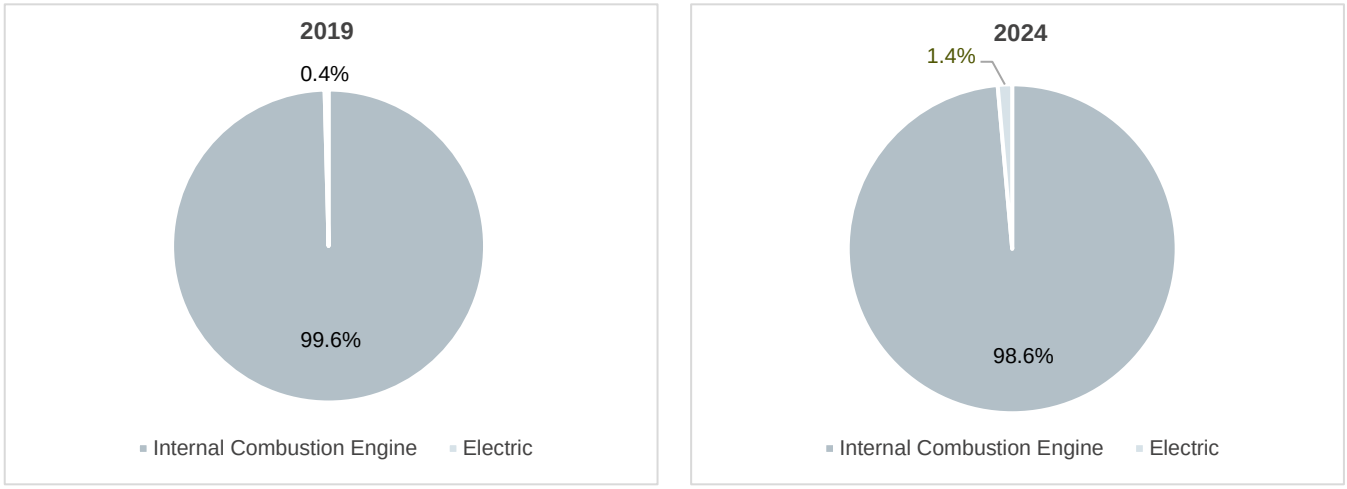
Motorcycles

Review of global motorcycles sales volume by displacement type

While fuel efficiency reigns, demand for higher cc motorcycles is rising globally, even in developing economies. Soaring disposable income fuels a desire for adventure riding, and improved infrastructure makes larger bikes more practical. Younger riders prioritise power and performance, while some cultures associate large motorcycles with freedom and status. Global demand for higher cc (>600 cc) motorcycles increased from ~12% in 2019 to ~13% in 2023.

Volume wise, in 2019, motorcycles with less than 600 cc segment recorded 7.3 million units and subsequently 1.0 million units for motorcycles greater than 600 cc segment. In 2024, the volumes for both categories reached 7.62 million units (CAGR of 0.9%) and 1.20 million units (CAGR of 3.6%) respectively.

Review of global motorcycles sales volume by propulsion type



Note: Above figures comprise sales in the US, Europe and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

Electric motorcycles offer a clean alternative, with zero tailpipe emissions and a potential reduction in running costs. Electric penetration in the motorcycle segment is still in the nascent stages; its share increased from ~0.4% in 2019 to ~1.4% in 2024. Electricity can be cheaper than gasoline, and electric motorcycles require less maintenance. Yet, electric motorcycles are not without hurdles. Limited range and lack of charging infrastructure, especially outside cities, make long journeys daunting. Upfront costs are currently higher due to battery technology, and performance might not match some gas-powered models in terms of power and acceleration. Thus, electric motorcycles remain niche and ICE variants will continue to dominate unless EV charging infrastructure improves significantly across geographies.

Scooters

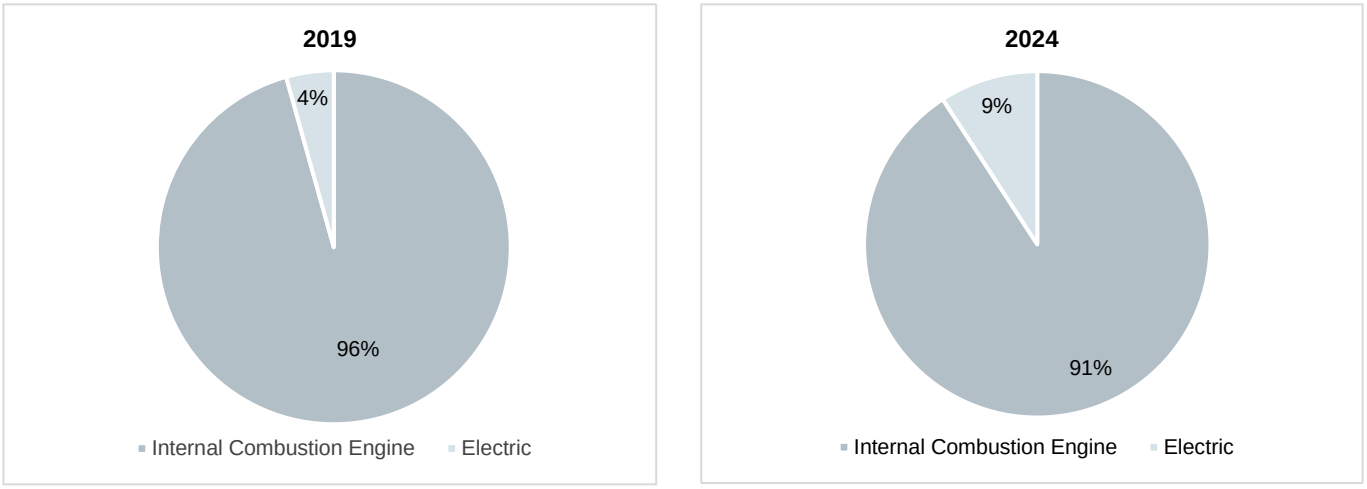
Review of global scooters sales volume by displacement type

Sub-125 cc scooters reign supreme in bustling cityscapes. Their unmatched fuel efficiency, user-friendliness and nimbleness make them ideal for navigating stop-and-go traffic and tight city streets. This dominance is fuelled by a booming rider base of young demographics and those seeking convenient transportation. Their affordability compared with larger scooters or motorcycles makes them a budget-conscious choice. Additionally, licensing requirements or limitations for larger engines in some regions favour the use of sub-125 cc scooters.

In contrast, larger-engine scooters have not seen widespread adoption. However, there is potential for growth in specific regions with well-developed highway networks. These scooters offer more muscle for tackling highway speeds and provide a more comfortable experience for longer distances. Advancements in electric scooters could be a game-changer, offering impressive power and acceleration while potentially eliminating the price disparity with smaller counterparts. Additionally, these scooters could embrace features such as improved suspension and infotainment for enhanced comfort and safety. In Southeast Asia, for example, larger scooters might be more prevalent due to factors such as road infrastructure and cultural acceptance as family vehicles.

Volume wise, in 2019, scooters with less than 125 cc segment recorded 4.1 million units and subsequently 3.77 million units for scooters greater than 125 cc segment. In 2024, the volumes for both categories reached 3.49 (CAGR of -3.1%) and 3.29 million units (CAGR of -2.7%) respectively.

Review of global scooters sales volume by propulsion type



Note: Above figures comprise sales in the US, Europe and ASEAN countries

Source: Mordor Intelligence, CRISIL Intelligence

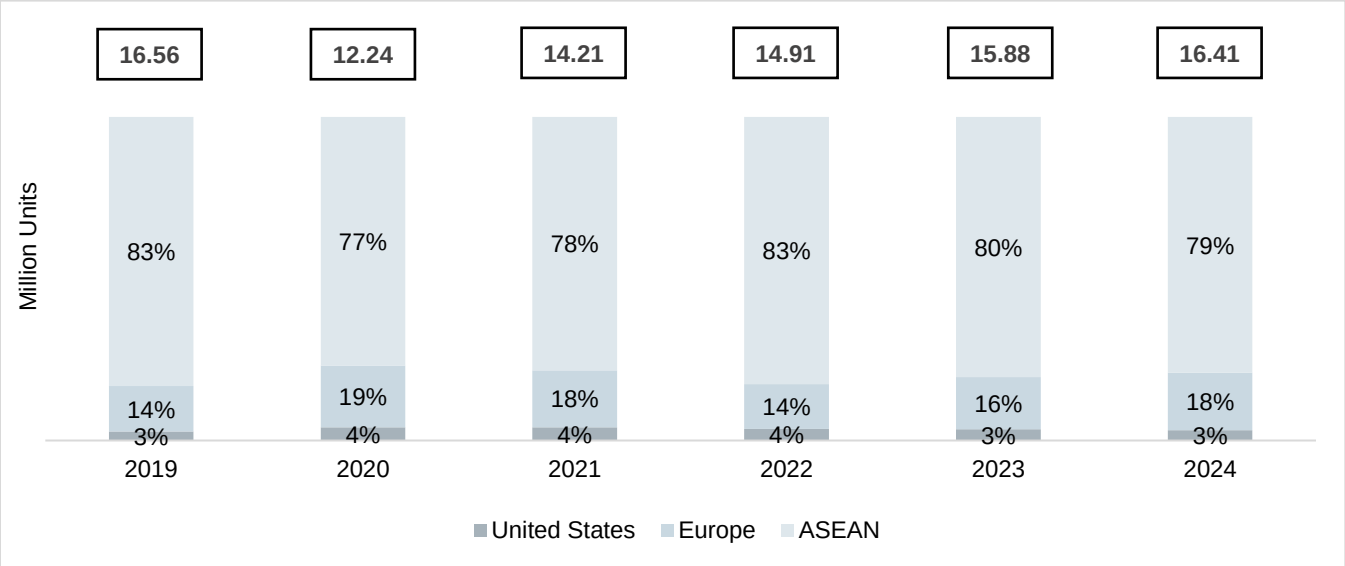
Gas-powered scooters are facing a fresh challenge from electric upstarts. The industry has played a big role in this battle. On the ICE side, manufacturers leverage the existing network of gas stations, keeping refuelling convenient for these scooters. Additionally, established technology allows them to offer a wider variety of affordable models, appealing to budget-conscious riders.

The electric scooter industry counters with a focus on environmental responsibility, highlighting their clean operation. They are also working on paring upfront costs to make electric scooters a more attractive option. However, the lack of widespread charging stations and the higher initial price tag compared with gas-powered models are still hurdles. The share of electric scooters has significantly increased from ~4% in 2019 to ~9% in 2024, driven by ASEAN countries, where scooters are accepted as a family vehicle and e-scooters have been managing to vouch on that trend with wider acceptance and increasing spending powers in these countries.

Looking ahead, both options will likely share the road. The industry's efforts to improve battery range and expand charging infrastructure will be key for electric scooters to gain wider acceptance. Additionally, government policies promoting cleaner transportation could give electric alternatives a significant edge.

Two-wheeler sales by geography

Review of global two-wheeler sales volume share by geography

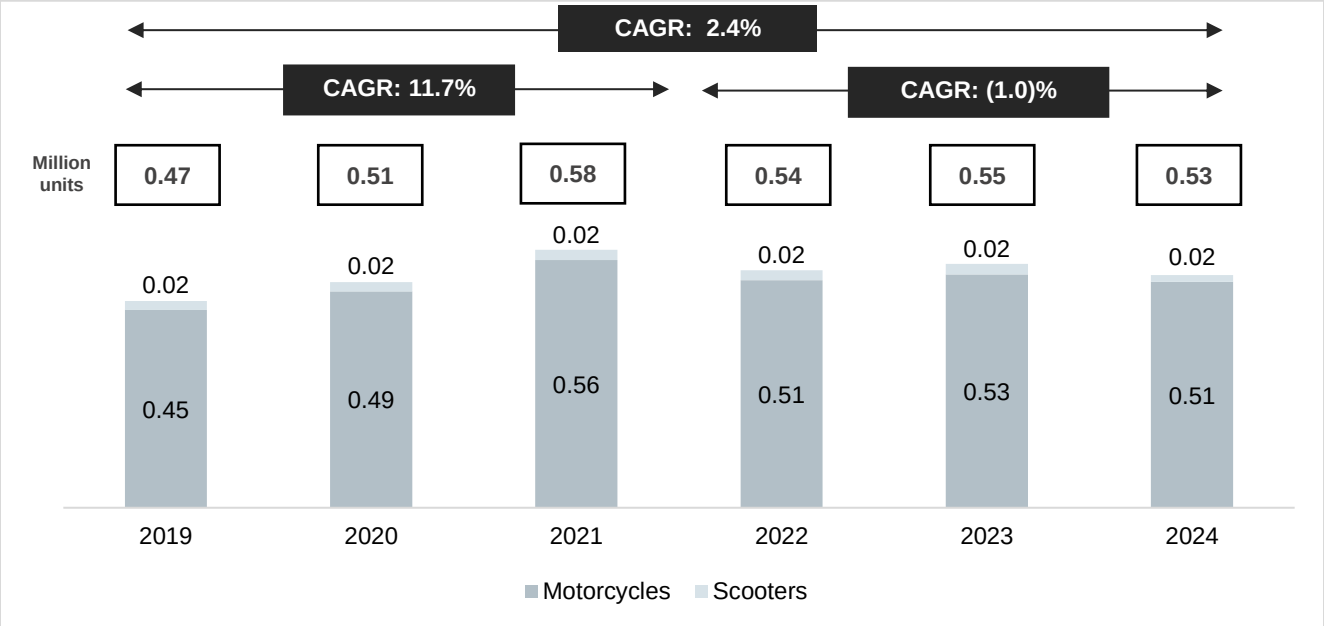


Source: Mordor Intelligence, CRISIL Intelligence

Demand for two-wheelers is led by ASEAN countries (75-85% share) for the past 5 years, ahead of Europe (15-20%) and the US (3-5%). Factors such as rising disposable income, growing middle-class segment, government support and significant rise in tourists' rental preferences for commute have contributed to the increased demand for two-wheelers in this region.

United States

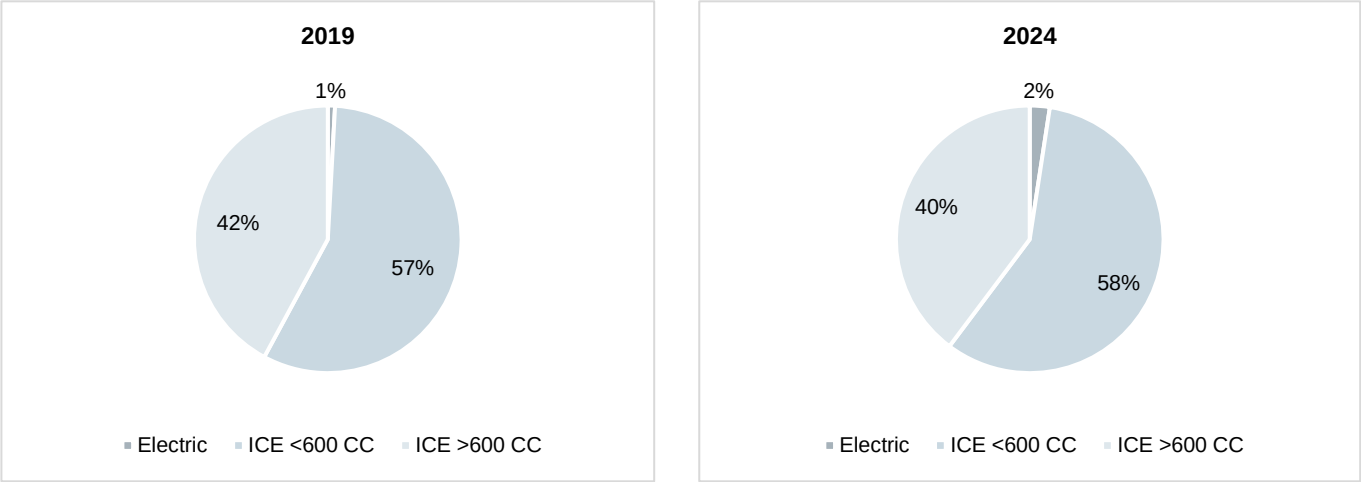
Review of two-wheeler sales volume in the US



Source: Mordor Intelligence, CRISIL Intelligence

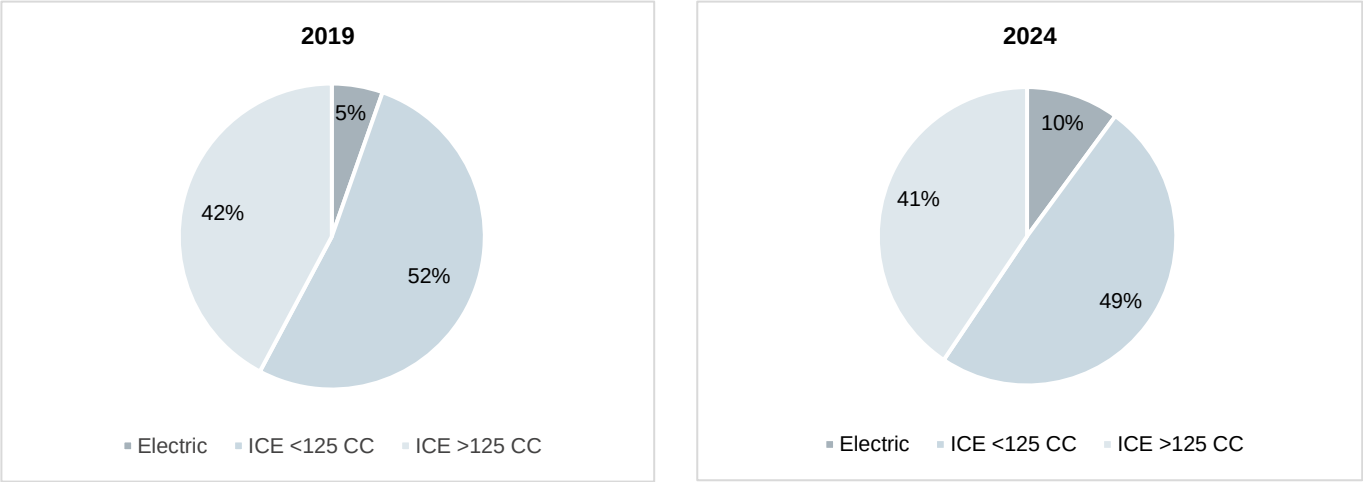
The US market is predominantly a motorcycle market, with a ~95%+ share in sales. In fact, within motorcycles, the premium models are the most preferred. Two-wheelers are viewed as lifestyle vehicles in these countries rather than a primary mode of transport.

Review of motorcycles sales volume by displacement type



Source: Mordor Intelligence, CRISIL Intelligence

Review of scooters sales volume by displacement type



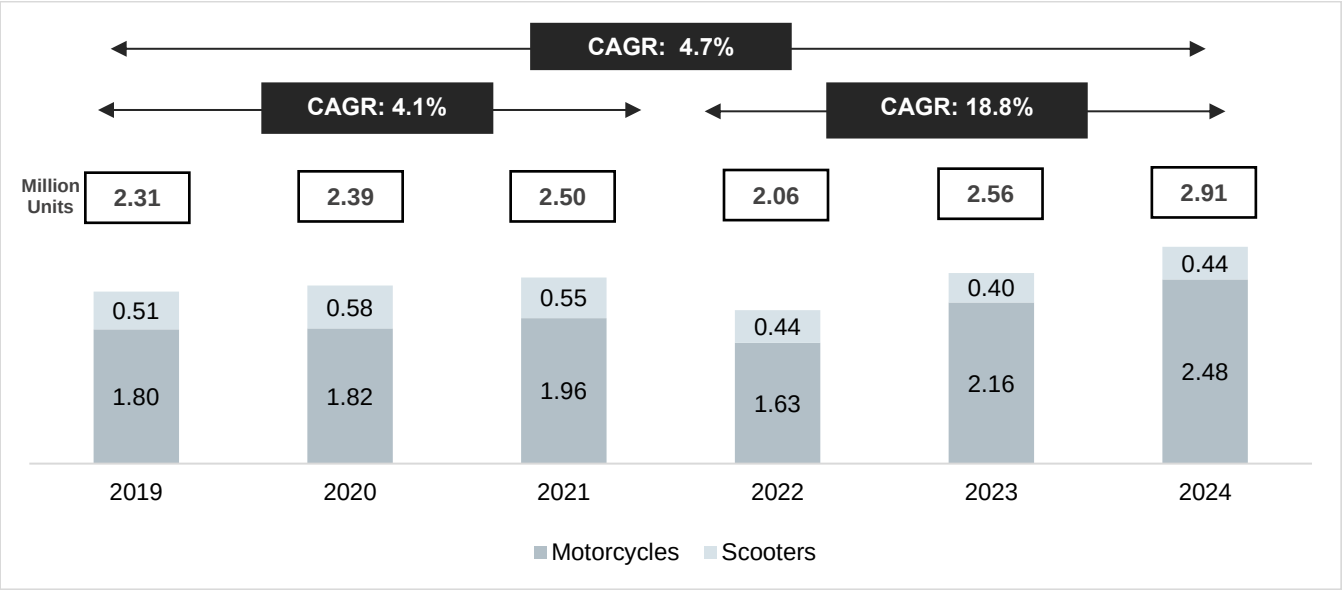
Source: Mordor Intelligence, CRISIL Intelligence

Electric scooters have not quite taken off yet, with sales mainly concentrated in urban areas. While they offer an eco-friendly option, a higher price tag and limited charging network keep them from widespread adoption.

The table toppers of the US scooter market are the smaller, fuel-efficient models under 125cc with ~52% market share as of 2019. Their affordability, nimble size and good gas mileage make them ideal for navigating city streets and conquering short commutes. In contrast, larger scooters, exceeding 125cc, have not gained much traction as far as volumes are concerned. However, in the overall scooter segment, they have been able to hover in the range of 40-45% between 2019 and 2024. Electric scooters have gained traction over the years with penetration reaching from ~5% in 2019 to almost double i.e. ~10% in 2024.

Europe

Review of two-wheeler sales volume

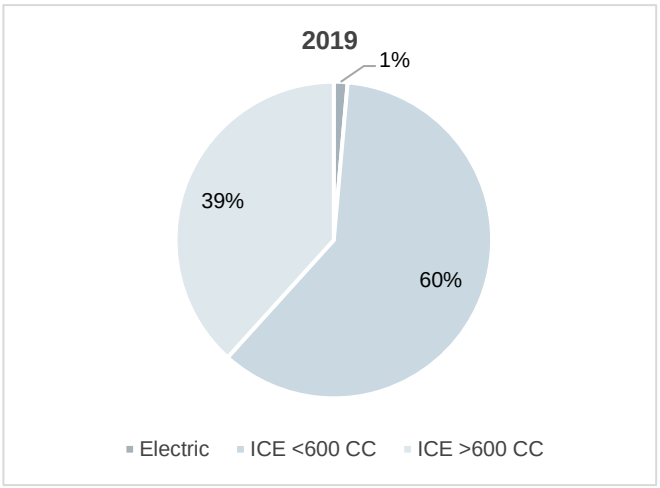


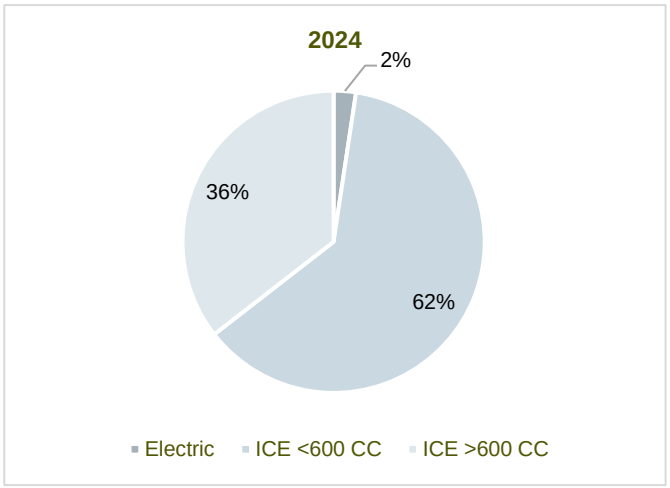
Source: Mordor Intelligence, CRISIL Intelligence

There has been a surge in the popularity of two-wheelers in the region due to a growing need for efficient and timely last-mile delivery services. This has resulted in an increased demand for these vehicles, which offer a convenient and cost-effective mode of transportation for small deliveries and other similar requirements.

Major countries in Europe, including Germany, the UK, Spain, France, Italy and Norway, experienced an increase in motorcycle and scooter sales. In 2023, Europe observed a rise in motorcycle sales, with ~2.56 million units sold, up 24.2% on-year and the growth continued in 2024 as well, with ~2.91 million units sold (up 13.7% on-year). Demand for motorcycles and scooters is on the rise in crowded urban areas due to the convenience of commuting on two-wheels rather than four. With increased pollution levels and decreased air quality in Europe, demand for electric scooters and motorcycles has jumped.

Review of motorcycles sales volume by displacement type

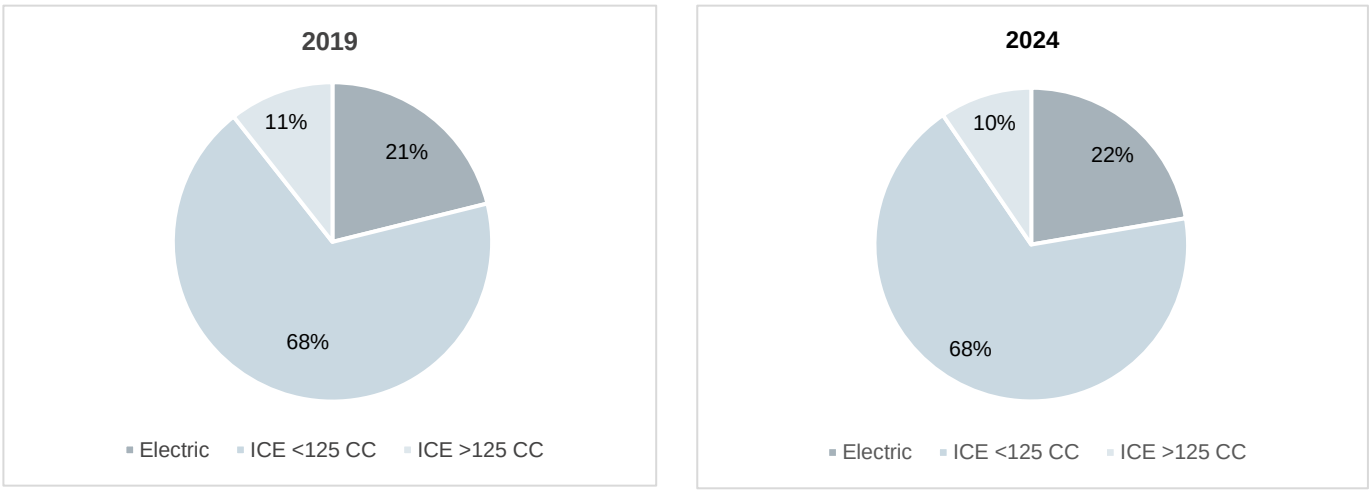




Source: Mordor Intelligence, CRISIL Intelligence

The German motorcycle industry experienced a positive start in 2023, becoming the third largest in Europe. Same trend has continued in 2024 as well. Germany is renowned for its highly developed automotive sector, housing numerous distinguished brands like BMW Motorrad, MZ, DKW, Horex, Kalex, that manufacture and distribute vehicles globally. However, motorcycles constitute only a small portion of Germany's transportation manufacturing industry.

Review of scooters sales volume by displacement type



Source: Mordor Intelligence, CRISIL Intelligence

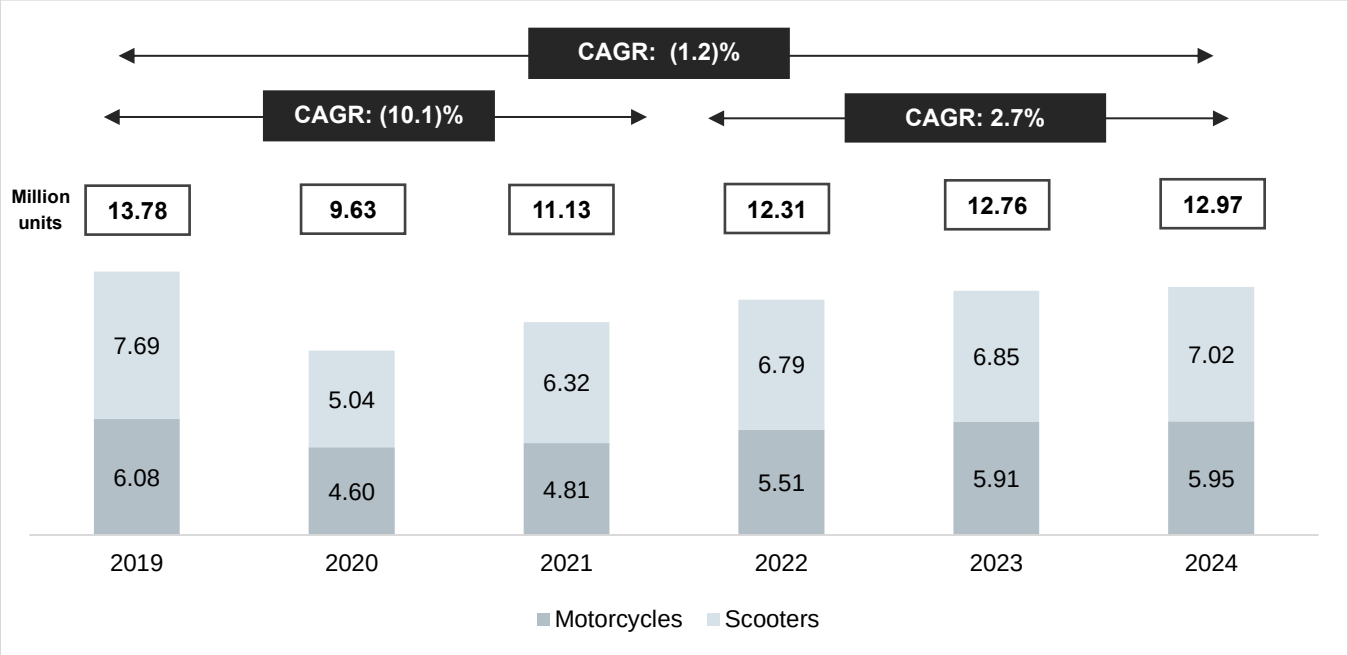
The European scooter market underwent a dramatic shift from 2019 to 2024, with a surge in demand for electric alternatives. Traditionally, scooters have thrived in Europe due to their practicality and affordability. Their manoeuvrability makes them ideal for navigating congested city streets and tight parking spaces.

However, electric scooters are rapidly changing the landscape. A few of the reasons for that are – regulatory landscape in Europe that focuses on stringent emission regulations, favourable financial support programs like for e.g., subsidies on purchase price, tax breaks, and even free scooter registration in some regions significantly reduce the barrier to entry for e-scooter adoption, and they also provide fleet operator support wherein some of the European cities provide financial backing to e-scooter fleet operators, encouraging them to expand their services and making e-scooters more readily available.

ASEAN

The ASEAN region is another sizeable contributor to overall global two-wheeler sales. Two-wheelers are the primary mode of transportation for a sizeable portion of the customer base within the ASEAN region. During 2019-23, two-wheeler sales in the ASEAN region shrunk at 1.9% CAGR with major contributors witnessing a contraction—Indonesia (1% CAGR fall), Vietnam (6.2% CAGR drop), Philippines (2.3% CAGR decline). Thailand, on the other hand, clocked a 2% CAGR growth compared with 2019 levels.

Review of ASEAN two-wheeler sales volumes

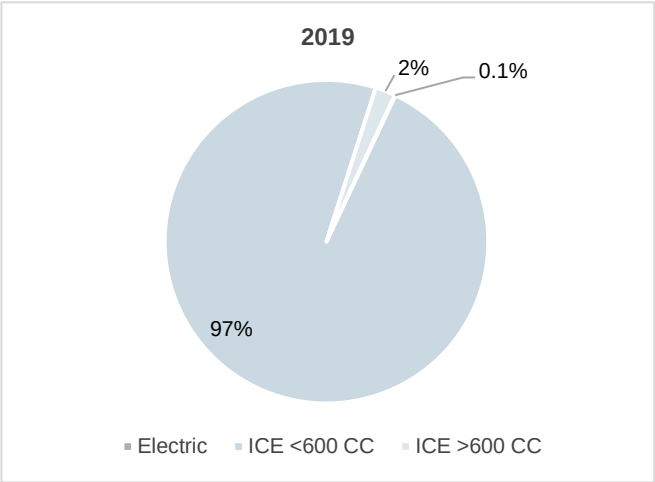


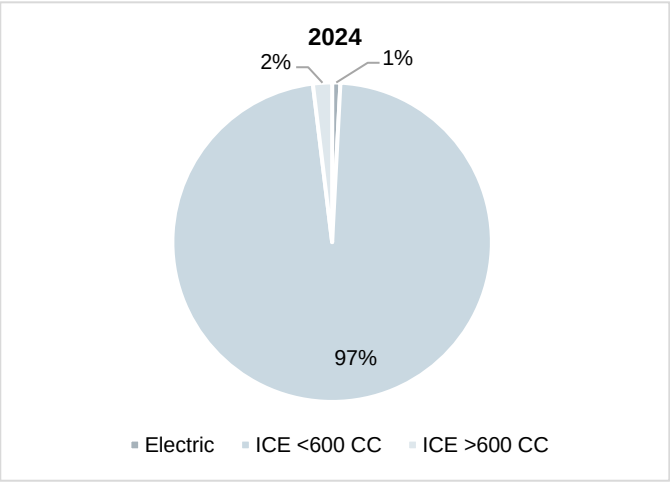
Source: Mordor Intelligence, CRISIL Intelligence

The region offers competitive labor costs, a robust infrastructure, and access to major global markets through trade agreements such as Regional Comprehensive Economic Partnership. With a population exceeding 650 million and a growing middle class, it presents a substantial consumer base. Combined with the long history of political stability and well-established legal systems, which are conducive to foreign investment, the cost competitiveness and substantial OEM consumption opportunity

In ASEAN region, scooters are the leading contributors and enjoy high customer preference given their competitive pricing, ability to carry load, manoeuvrability and preference from women riders. However, during 2019-2024, scooter sales contracted at a faster pace of 1.8% CAGR compared with a 0.5% CAGR decline witnessed by motorcycles. Motorcycles clocked a faster pick-up after the pandemic-induced hiatus in some large contributing countries such as Indonesia and Thailand, thereby restricting the drop in overall motorcycle sales, whereas scooter sales contracted because of slower pick-up in Indonesia and the Philippines coupled with near-steady sales in Vietnam and Thailand.

Review of ASEAN motorcycle sales volumes by displacement type

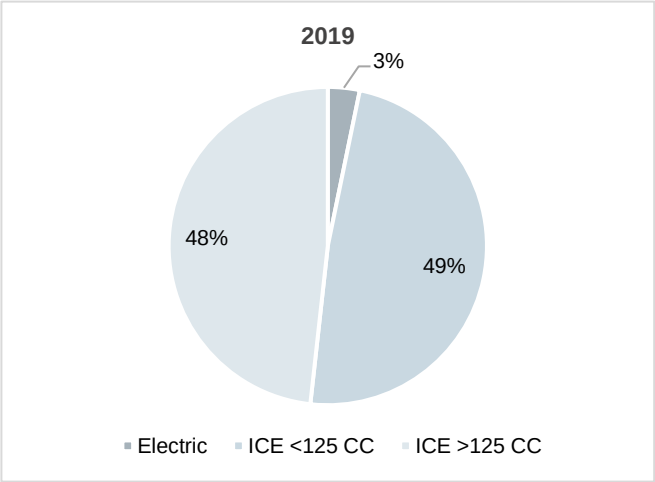


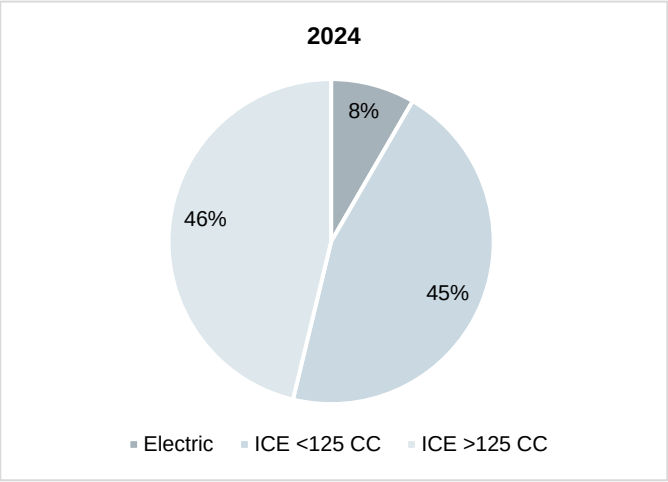


Source: Mordor Intelligence, CRISIL Intelligence

The motorcycles industry in the ASEAN region is heavily driven by motorcycles with smaller engines (<600 cc) with ~98% share in the overall market, which has remained constant for the past six years. EV penetration is much lower in motorcycles, although it has grown from 0.1% in 2019 to ~1% in 2024.

Review of ASEAN scooters' sales volumes by displacement type





Source: Mordor Intelligence, CRISIL Intelligence

Although overall scooter sales declined at a CAGR of 1.8% from 2019 to 2024, e-scooters clocked a healthy 18.8% CAGR growth, led by lower operating costs, expanding portfolio and continued government support. Healthy growth in e-scooter sales supported EV penetration within scooters—from 3% in 2019 to 8% in 2024.

For instance, in Thailand, where two-wheelers are the most popular mode of transportation, electric motorcycles and scooters are making a significant impact. These electric scooters are relatively inexpensive, costing about 84,000 Thai Baht or USD 2,500 in Bangkok.

Major global two-wheeler manufacturers

BMW AG

BMW AG, founded in 1916, is a German multinational company that specialises in the manufacturing of luxury automobiles, motorcycles and engines. BMW AG is involved in producing and marketing cars and motorbikes.

BMW has a global presence with manufacturing plants and sales networks in various countries worldwide. They have production facilities in Germany, the US, China, South Africa, and other locations. In 2024, BMW reported sales of 210,408 motorcycles worldwide.

Harley-Davidson Inc

Founded in 1903 and based in Milwaukee, Wisconsin, Harley-Davidson is one of the most iconic motorcycle brands globally. It is renowned for its heavyweight motorcycles tailored for cruising on highways. Harley-Davidson's business is segmented into three main areas: the Harley-Davidson Motor Company, which includes the design, manufacture, and sale of cruiser, touring, and other styles of motorcycles; the LiveWire segment, which focuses on electric motorcycles; and the Harley-Davidson Financial Services, offering financing, insurance, and other services to dealers and customers. It has manufacturing facilities in the United States, Brazil, India, and Thailand, which allow it to support its global operations. In 2024, Harley sold 1,51,229 units of motorcycles globally, compared to the sales of 1,62,771 units in 2023.

Ducati Motor Holding SPA

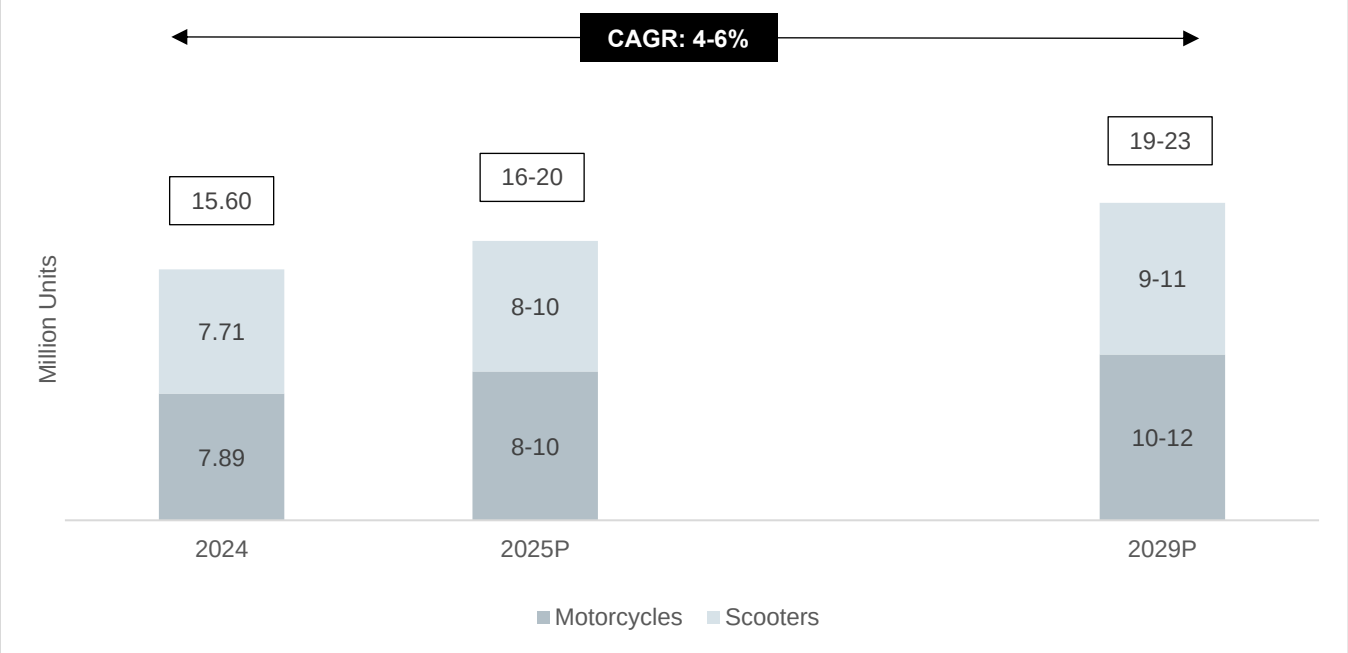
Ducati Motor Holding SPA, founded in 1926, is an Italian motorcycle manufacturer owned by the German automotive group Audi through its subsidiary Lamborghini. Ducati is renowned for its high-performance motorcycles featuring powerful engines, innovative design and advanced technologies. The company's product line-up includes a range of motorcycles, such as the Monster, Multistrada, and Panigale, alongside a growing segment of electric bikes and accessories. Ducati operates on a global scale and has a significant presence in both developed and emerging markets. Ducati closed 2024 with 54,495 motorcycles delivered to its customers worldwide.

Yamaha Motor Corporation

Established in 1955, headquartered in Iwata, Shizuoka, Japan and originally known for musical instruments, Yamaha Motor Co. Ltd is a major Japanese manufacturer of motorcycles, marine products and other motorised products. In fiscal 2024, net sales were 2,576.2 billion yen (an increase of 161.4 billion yen or 6.7% compared with the previous fiscal year) and operating income was 181.5 billion yen (a decrease of 62.4 billion yen or 25.6% decline). In terms of overall motorcycle sales in 2024, Yamaha sold 4.8 million units, a year-on-year increase of 4.3%.

Outlook of the global two-wheeler industry (2024 to 2029)

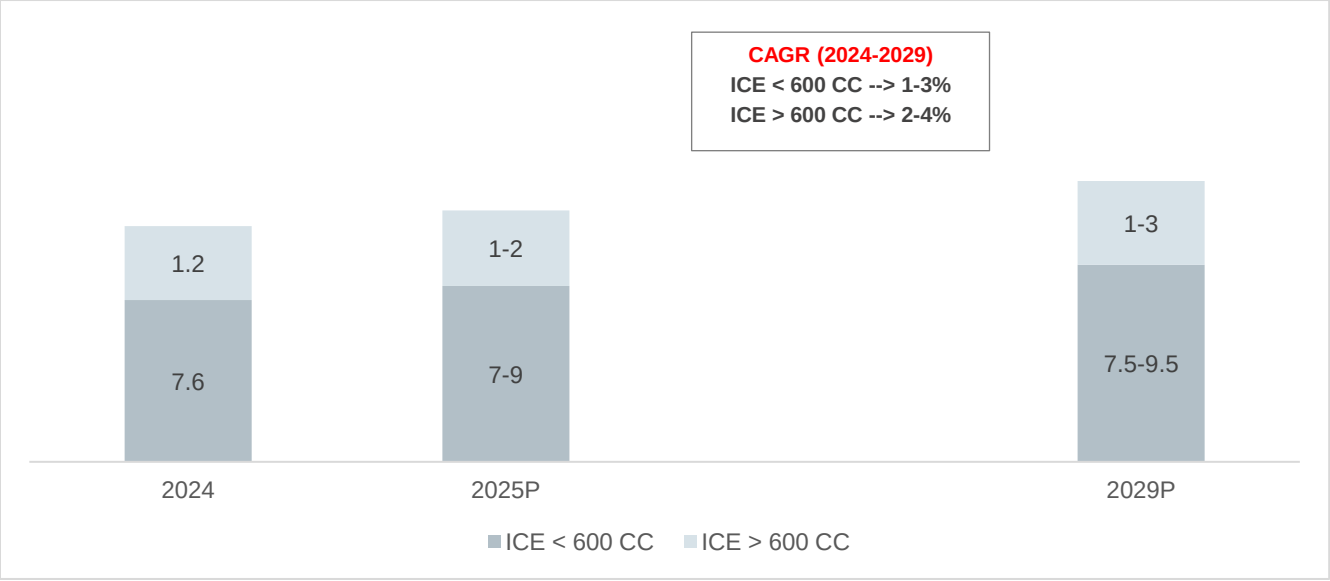
Outlook of two-wheeler sales volumes by vehicle type



Source: Mordor Intelligence, CRISIL Intelligence

Overall two-wheeler volumes are anticipated to clock a CAGR of 4-6% between 2024 and 2029, reaching 19-23 million units in 2029 from 15.60 million units in 2024.

Outlook of motorcycles sales volumes by cc segmentation



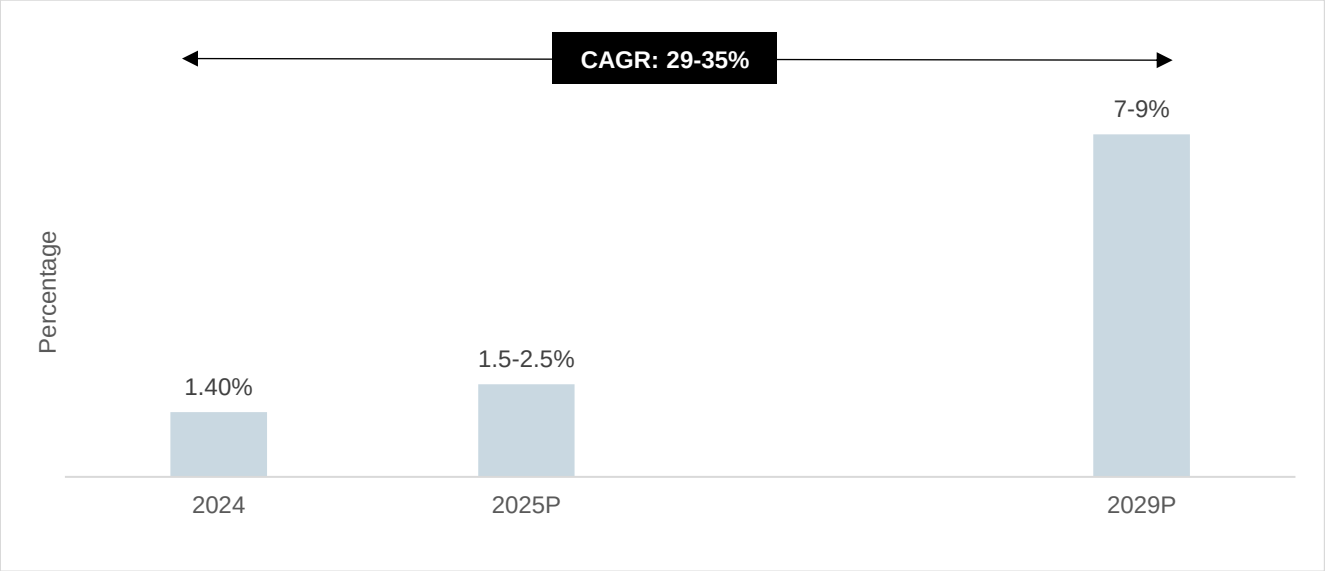
Source: Mordor Intelligence, CRISIL Intelligence

Motorcycles lesser than 600 cc are anticipated to clock a CAGR of 1-3% between 2024 and 2029 whereas higher cc motorcycles (greater than 600 cc) are anticipated to clock a growth of 2-4% between the same period.

Outlook of EV penetration in the global two-wheelers industry (2024 to 2029)

Environmentally conscious consumers and burgeoning urban populations are demanding cleaner, more maneuverable transportation options, thus making way for electric two-wheelers in the market. Governments are responding with subsidies and infrastructure investments, while on the financing front, fintech companies are creating financing solutions such as low-interest loans and battery leasing to make electric two-wheelers more accessible.

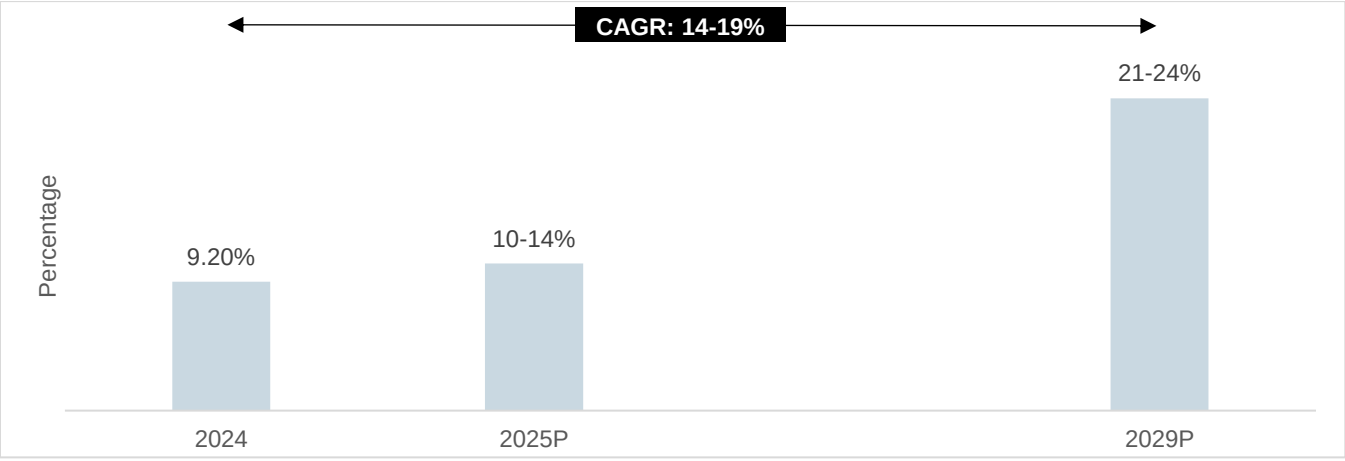
Outlook of overall EV penetration in the global motorcycles industry



Source: Mordor Intelligence, CRISIL Intelligence

EV penetration in motorcycles shall globally witness an upward trajectory from 1.4% in 2024 to 7-9% in 2029. With scooters taking the charge in terms of electrification, EV penetration in motorcycles will move at a slower pace. Increasing affordability and focusing on providing more options shall remain the key pointers for major OEMs to drive the motorcycles industry.

Outlook of overall EV penetration in global scooters industry



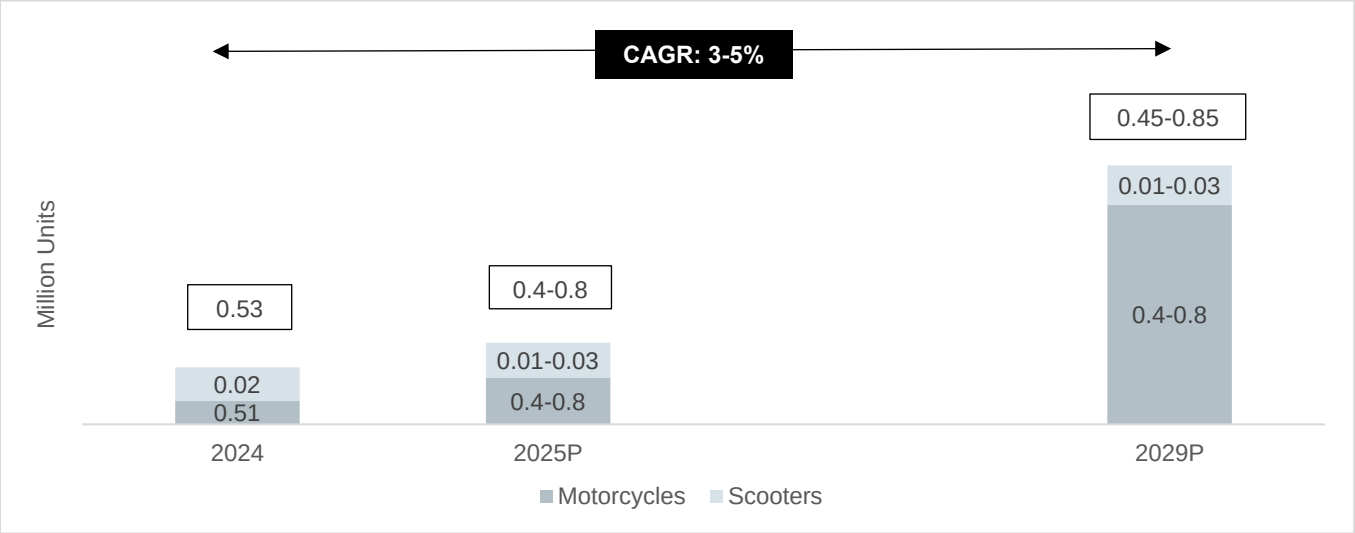
Source: Mordor Intelligence, CRISIL Intelligence

EV penetration in the scooters industry globally shall witness a significant increase from 9.2% in 2024 to 21-24% in 2029. Technological advancements and government support shall remain the key growth drivers for this segment. However, macroeconomic trends in major geoagraphies will bear watching for this industry to flourish in coming years.

By geography type

United States

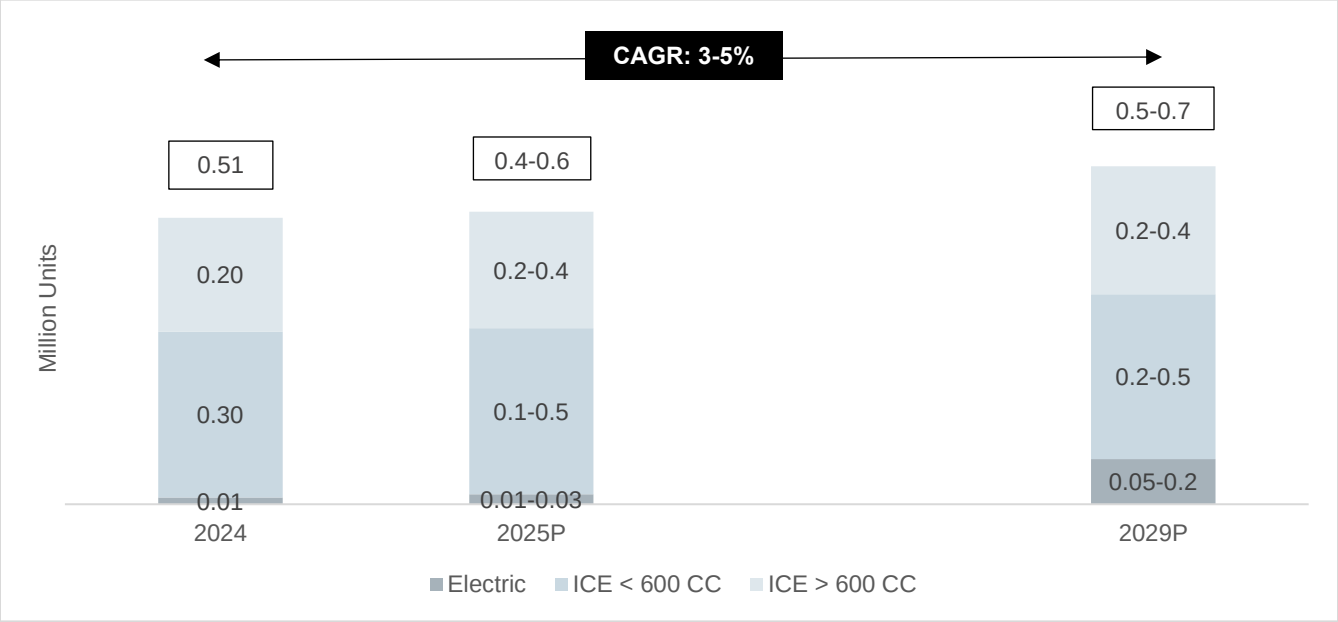
Outlook of two-wheeler sales volumes in the US by vehicle type



Source: Mordor Intelligence, CRISIL Intelligence

Two-wheeler volumes in the US are anticipated to clock a CAGR of 3-5% between 2024 and 2029, reaching 0.45-0.85 million units in 2029 from 15.60 million units in 2024. Factors such as congestion in major cities, popularity of adventure touring and evolution of electric alternatives shall remain the key drivers for the two-wheeler industry in the US.

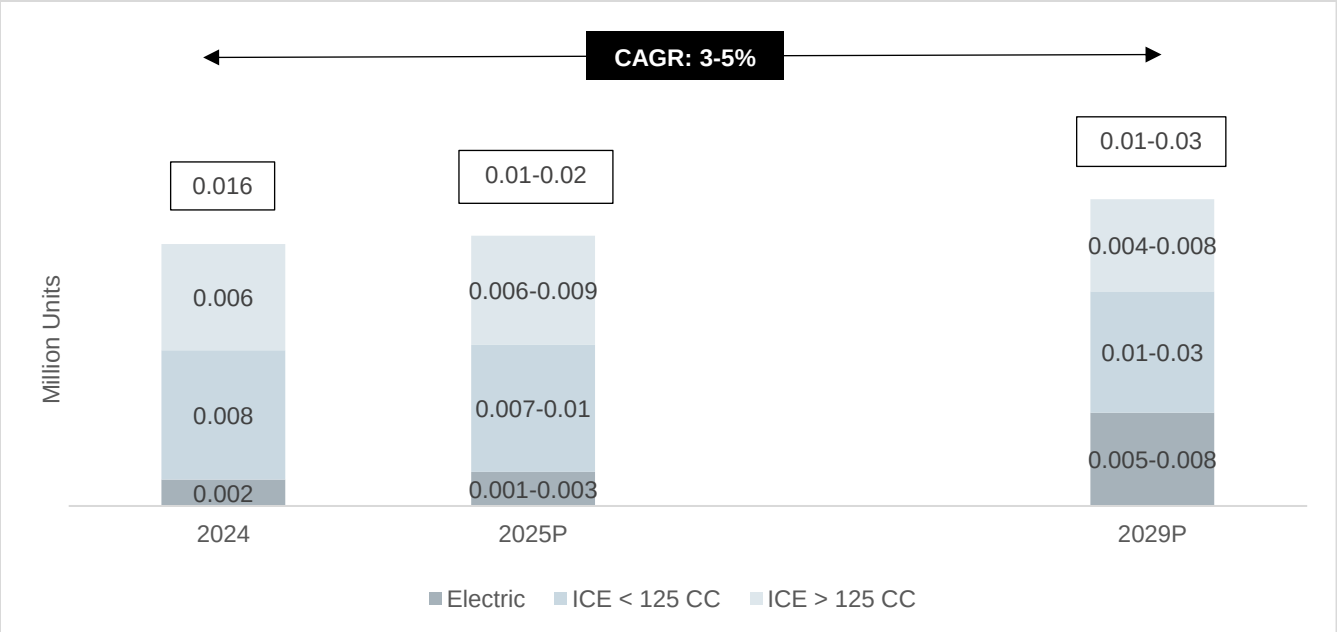
Outlook of motorcycles sales volumes in the US by displacement type



Source: Mordor Intelligence, CRISIL Intelligence

Electric motorcyles, though lower in volumes, are expected to clock a CAGR of 43-47% between 2024 and 2029, followed by growth in the premium motorcycles segment (>600 cc), which logged a CAGR of 1-4% during the period. Motorcycles with smaller engines (<600 cc) shall remain stagnant in terms of volumes for the next five years with sales hovering at 0.2-0.5 million units.

Outlook of scooter sales volumes in the US by displacement type

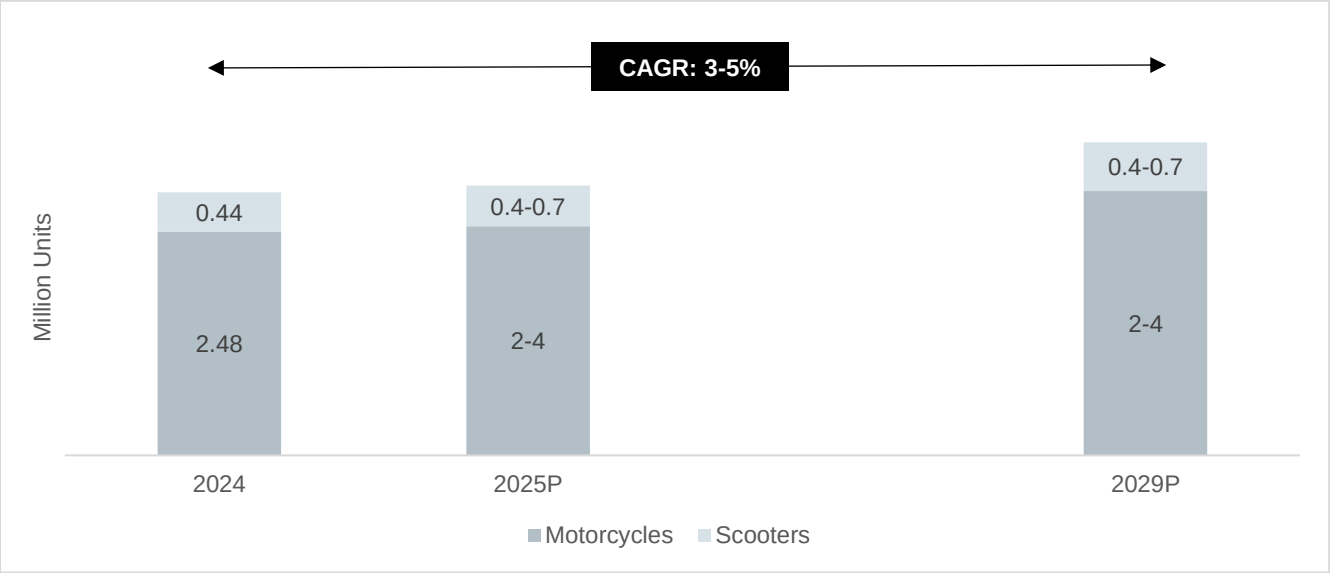


Source: Mordor Intelligence, CRISIL Intelligence

Scooter volumes in the US are anticipated to clock a CAGR of 3-5% between 2025 and 2030 with electric scooters dominating in terms of growth, logging a CAGR of 25-30% in the same period with volumes reaching 0.006-0.01 million units. Higher cc scooters are anticipated to witness stability in terms of volume growth duirng the period. However, lower cc scooters will see a decline of 1-2% in the same period.

Europe

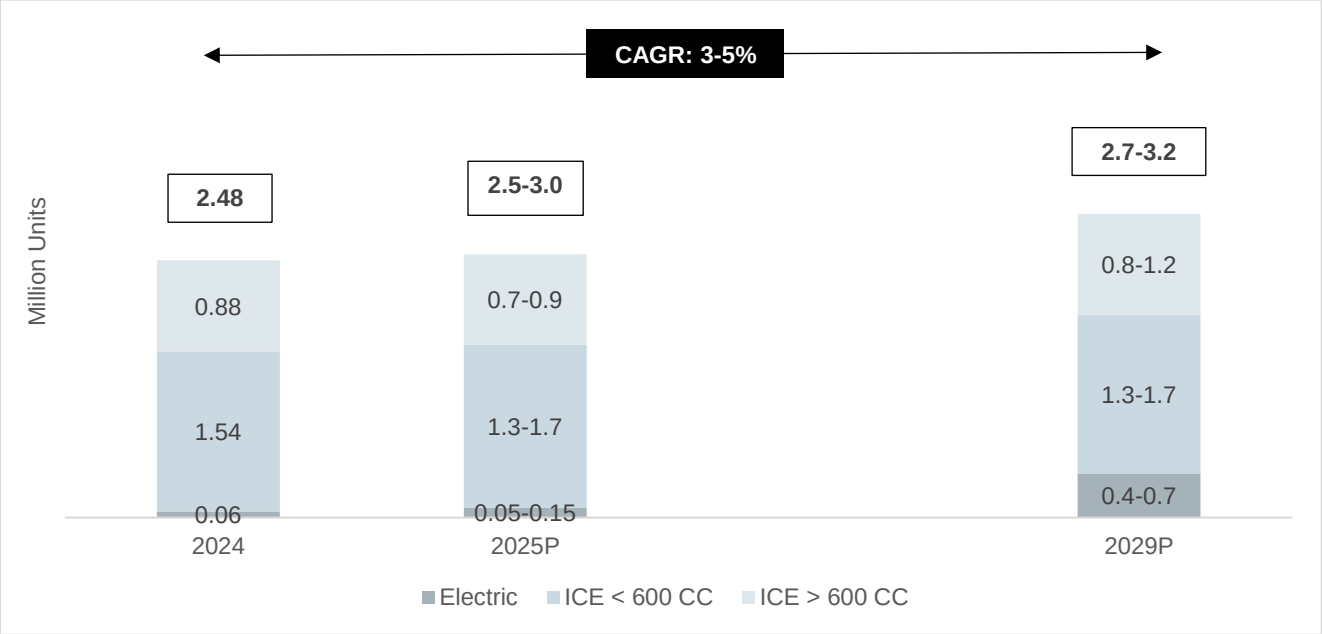
Outlook of two-wheeler sales volumes in Europe by vehicle type



Source: Mordor Intelligence, CRISIL Intelligence

The two-wheeler industry in Europe is anticipated to log a CAGR of 3-5% between 2024 and 2029, with motorcycles cloccking a CAGR of 3-4% and scooters registering a CAGR of 4-5% for the same forecast period. The two-wheelers segment, including electric scooters and motorcycles, is gaining popularity owing to its agility and eco-friendliness. Manufacturers who cater to the varied needs of European riders, offering a range of choices in size, power, environmental impact and affordability, will be the ones leading the pack. Sustainability and innovation will hold the key to growth going ahead, with electric options likely gaining significant ground alongside established motorcycles.

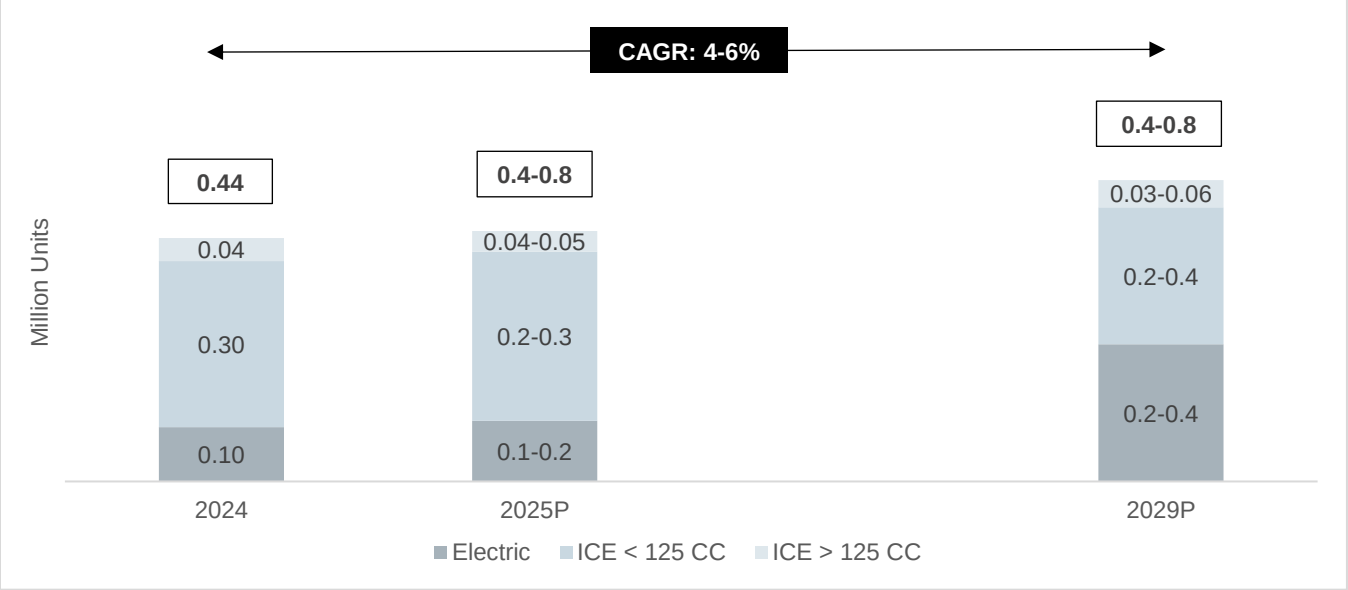
Outlook of motorcycle sales volumes in Europe by displacement type



Source: Mordor Intelligence, CRISIL Intelligence

The motorcycles industry in Europe is expected to post a CAGR of 3-5% between 2024 and 2029 with electric alternatives dominating growth at a CAGR of 46-50% during the period. Volumes of electric motorcycles are anticipated to reach 0.4-0.7 million units. Higher cc motorcycles will witness a modest growth of 1-3% during the period as the European market observes an increasing trend in premium and luxury purchases. Lower cc motorcycles shall witness a growth at 0-(2)% during the period.

Outlook of scooter sales volumes in Europe by displacement type

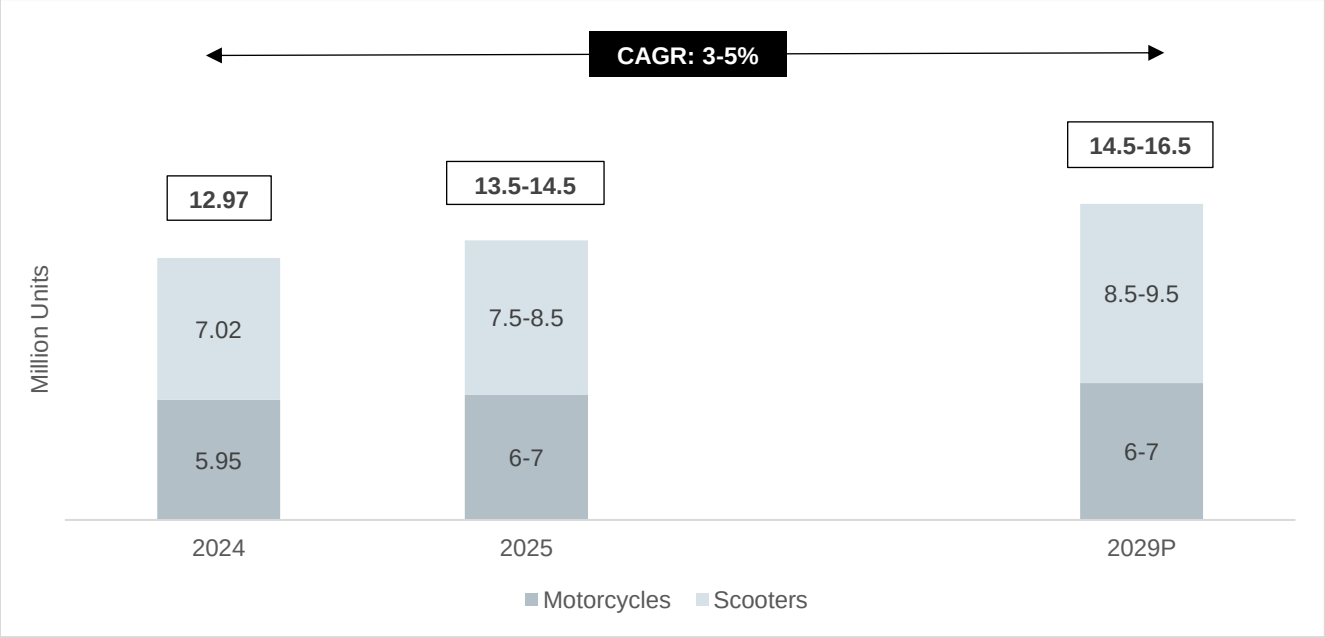


Source: Mordor Intelligence, CRISIL Intelligence

European scooter sales will likely log a CAGR of 4-6% during 2024 to 2029, mainly led by growth in the electric scooters segment. E-scooters will witness a growth of 18-23% with volumes reaching 0.2-0.4 million units in 2029, approximately 2x of where the industry stands in 2024. ICE alternatives shall see a decline in the coming years as electric evolution in the scooters segment takes charge.

ASEAN

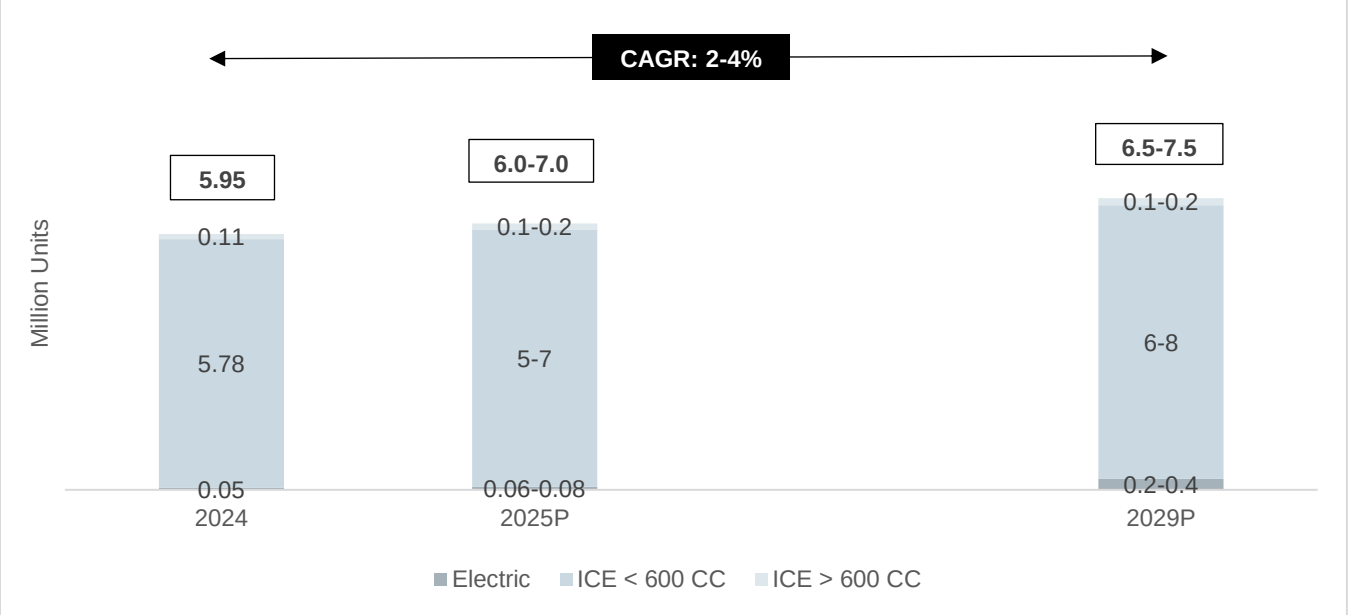
Outlook of two-wheeler sales volumes in the ASEAN region by vehicle type



Source: Mordor Intelligence, CRISIL Intelligence

The two-wheeler market in the ASEAN region is likely to clock a CAGR of 3-5% during 2024 to 2029 with the scooters segment holding the majority share (~57%). Scooters shall continue to dominate two-wheeler markets in the ASEAN region as congestion in cities, tourist preferences for two-wheeler commute and cultural acceptance of the two-wheeler as a family vehicle shall remain key drivers for the industry.

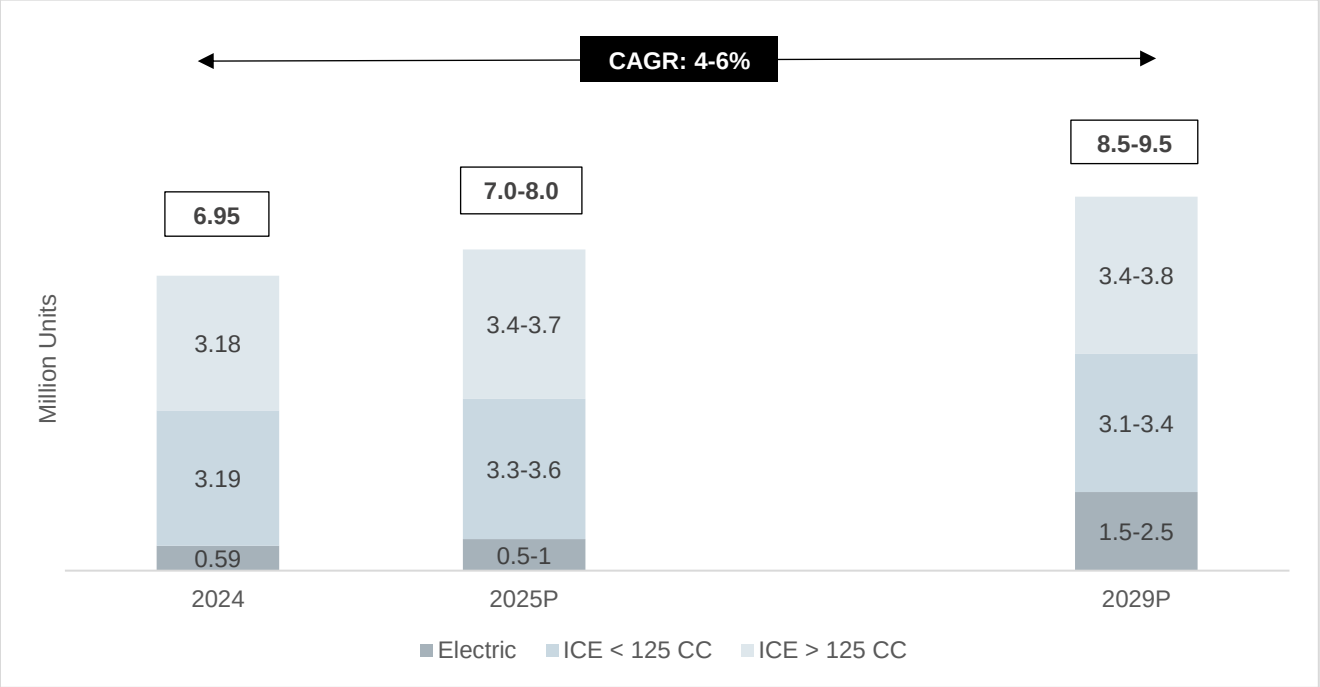
Outlook of motorcycle sales volumes in the ASEAN region by displacement type



Source: Mordor Intelligence, CRISIL Intelligence

Affordability and limitations in tech advancements (compared to scooters) shall keep the demand for electric motorcycles under certain limits. ICE alternatives shall log a CAGR of 1-3% during the period with the <600 cc segment dominating volumes.

Outlook of scooter sales volumes in ASEAN region by displacement type



Source: Mordor Intelligence, CRISIL Intelligence

The scooters segment in the ASEAN region will clock a CAGR of 4-6% during 2024 to 2029 with e-scooters dominating the segment in terms of growth. E-scooters shall grow at a CAGR of 23-27% during the period. Factors such as feature-rich scooters, affordable options and government support have been keeping demand for electric scooters on a roll. ICE alternatives shall continue to remain dominant in the market in terms of volumes owing to their established legacy and increasing affordability over the time. However, their growth shall remain stagnant with higher and lower cc scooters both logging a CAGR of 1-2% during the period.

3. Review of the Indian automobile industry

Indian passenger vehicle industry

Review of the domestic passenger vehicles industry (fiscals 2019 to 2024)

Owing to improvement in macro-economic scenario, rising disposable incomes and expanding vehicle portfolios, the Indian PV industry witnessed stellar growth and PV sales reached a high of 3.4 million vehicle in fiscal 2019. The high growth until fiscal 2019 was led by steady GDP growth, increase in disposable incomes, new model launches, stable cost of vehicle ownership and increasing traction for sports utility vehicles (SUVs).

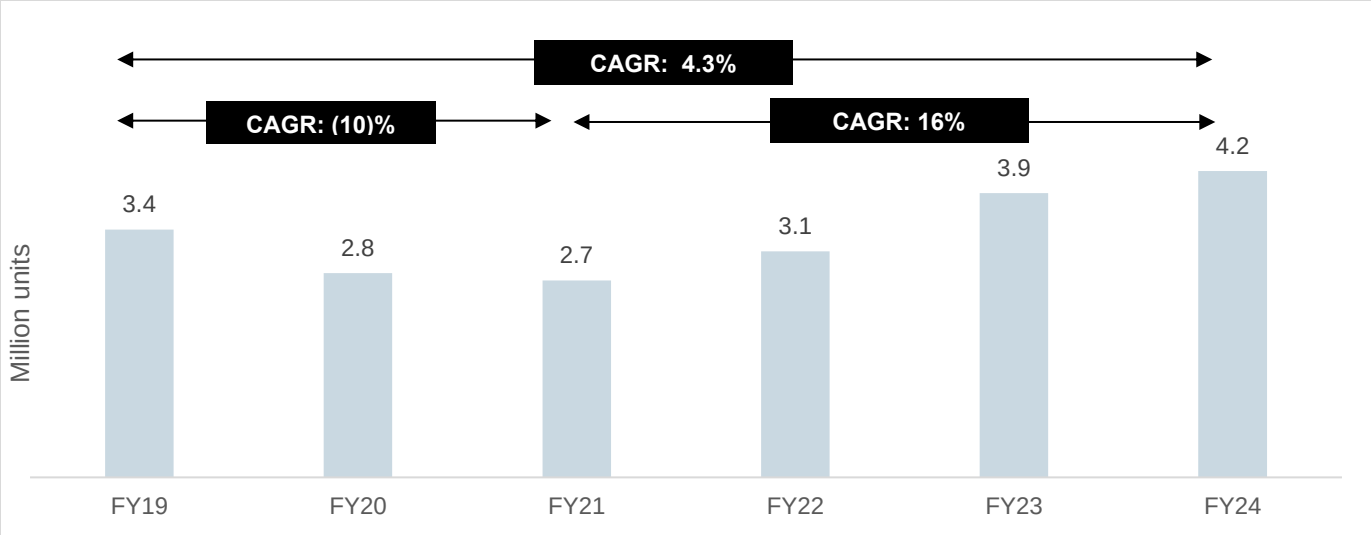
Between fiscals 2019 and 2024, India's domestic PV sales clocked 5% CAGR despite a sales contraction (10% CAGR) during fiscals 2019-2021. From the low base of fiscal 2021, PV sales bounced back and grew healthily to reach a historic high of 4.2 million vehicles in fiscal 2024, registering a CAGR growth of 16%.

In fiscal 2020, the economic contraction owing to the pandemic put pressure on vehicle sales. Other factors that heightened the pressure are the non-banking financial company (NBFC) liquidity crisis and halting of BS-IV vehicle production amid mandatory implementation of BS-VI norms from fiscal 2021. The industry also lost nearly half a month's sales during the end of the fiscal owing to the outbreak of Covid-19 and subsequent nationwide lockdown.

Fiscal 2024 marked the third year of consecutive growth in PV industry by recording 8% growth. This comes over a high base of fiscal 2023 which grew by 27%(almost double the growth of 13% in fiscal 2022) due to healthy pent-up demand created by two years of slump in sales volumes owing to a pandemic induced disrupted supply chain. The orderbooks of auto OEMs were further supported by plethora of launches in the growing UV (Utility vehicles) category, which had witnessed high traction, along with multiple facelifts of existing models and easing semiconductor supplies drove record sales in each quarter in fiscal 2024. The overall wholesale volumes settled at ~3.9 million units in fiscal 2023.

Historic production development (fiscals 2019-2024)

Review of domestic PV sales volume



Note: Figures in bracket are negative (Eg. (10) denotes negative 10)

Source: SIAM, CRISIL Intelligence

During fiscal 2024, growth momentum of the industry continued, albeit at a slower pace, backed by the continued traction for the SUV segment, intermittent launches and improvement in disposable income. On the high base of fiscal 2023, the industry grew 8% in fiscal 2024 to hit a record 4.2 million units.

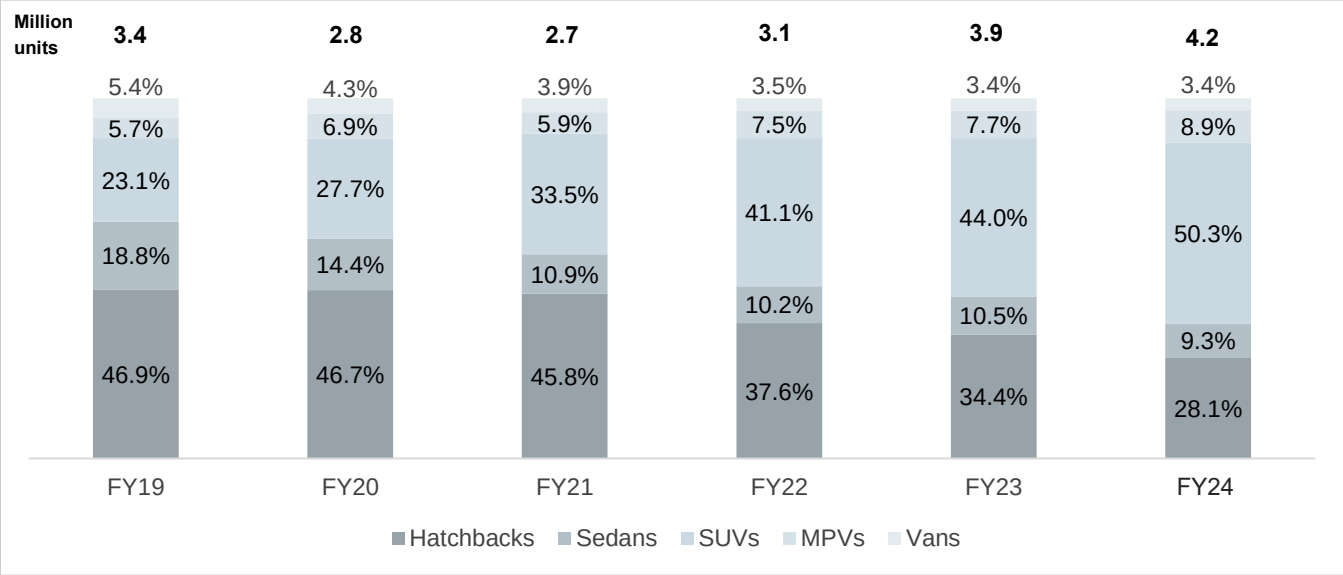
Segmental shifts amidst premiumisation

Based on body types, PVs in India are broadly classified into hatchbacks, sedans, SUVs, multipurpose vehicles (MPVs) and vans. Traditionally, domestic vehicle buyers have been cost conscious, with mileage and initial vehicle buying cost being the two key factors influencing the decision-making. Hence, the hatchback segment had been leading PV sales over the years primarily because of the lower ticket size and lower running costs, making them affordable to the average Indian customer.

However, with a growing share of younger buyers with global exposure, there is an increasing awareness and preference towards other parameters such as driving experience, safety, advanced features aesthetics and a comfortable ride due to poor road conditions, which are impacting the decision-making process. To address this change, OEMs such as Tata Motors and Hyundai have started incorporating enhanced vehicle safety in their recent launches. Several carmakers have introduced advanced features in top variants and gradually incorporated them in even the mid variants. Furthermore, rising disposable income has also given an impetus to growth in the SUV segment.

There has been a perceptible shift in the customer buying behaviour, with customers prioritising vehicle experience over costs and willing to pay a premium. They are also ready to accept longer waiting time for the desired vehicle. More and more customers are now opting to buy mid to top level variants that fall within their budgets. The shift towards premium vehicles is resulting in inter-segmental and intra-segmental shifts.

Segment-wise trends in the overall PV sales volume in India



Note: Figures above bars are the sales volume.

Source: SIAM, CRISIL Intelligence

CAGR for segment-wise trends in the overall PV sales volume in India - fiscals 2019 to 2024

	Hatchbacks	Sedans	SUVs	MPVs	Vans
FY19-24 CAGR	-7.7%	-11.2%	19.5%	11.7%	-6.9%

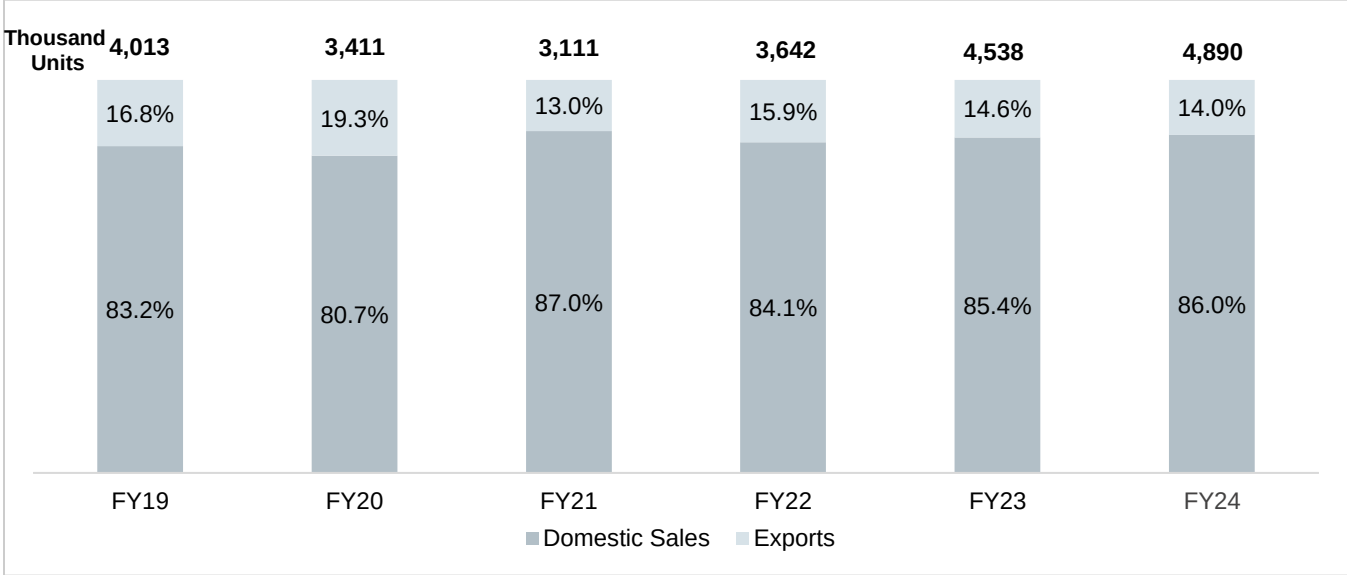
Note: Figures above bars are the sales volume.

Source: SIAM, CRISIL Intelligence

Split of industry by domestic sales and exports

The Indian PV makers are largely domestic-focused, with domestic sales accounting for 86% of the total sales in fiscal 2024. Share of exports in total sales contracted from 16.8% in fiscal 2019 to 14% in 2024 because of moderate growth in the global automobile industry and major OEMs focusing on catering to the fast-growing domestic market. Following a ~38.6% on-year decline in fiscal 2021, exports rose a sharp 42.9% in fiscal 2022 and 14% in fiscal 2024 owing to demand from emerging countries further supported by push from the major OEMs.

Domestic sales and exports of domestic PVs (fiscals 2019-2024)



Source: SIAM, CRISIL Intelligence

CAGR for domestic sales and exports of domestic PVs - fiscals 2019 to 2024

	Domestic Sales	Exports
FY19-24 CAGR	4.5%	8.3%

Source: SIAM, CRISIL Intelligence

Manufacturers from India has grown a stable base in African and Latin American countries over the years. Good brand recognition of Indian brands for entry level cars. Share of exports to South Africa increased to 33.3% in fiscal 2024 from ~22% in fiscal 2022. South Africa has become the major export market surpassing Mexico (whose share declined from ~29% in fiscal 2018 to 12.5% in fiscal 2024), due to higher demand for UV (Utility vehicles) segment. Newer markets such as Saudi Arabia and USA have also seen increase in exports.

Anticipated improvement in economic growth, push from OEM's with India as the base for exports of certain models is projected to boost exports resulting in 6-8% growth in fiscal 2025. Indian OEM continued to exports higher number of small cars with 5 out 10 top exported models being small cars. Affordable prices along with higher fuel efficiency has led to increased in demand for small cars especially from emerging markets in Latin America and Africa.

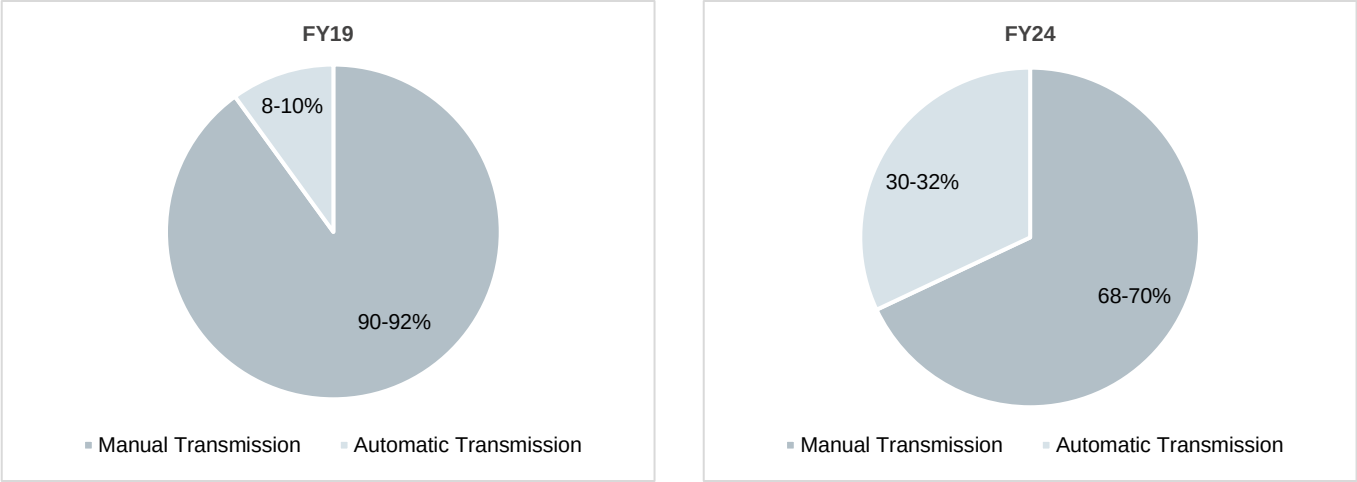
PV production by transmission type

Transmission components, which transfer power from engine to the wheels, are key components of vehicles. There are various types of transmissions available depending on the level of automation in the transmitting power from engine to the wheels.

These technologies differ in terms of their level of automation and reduction in driving strain. In semi-automatic transmission, transmission technologies such as automated manual transmission (AMT) and intelligent manual transmission (iMT) are available. In AMT, in place of the manually operated gear lever and clutch pedal, a hydraulic actuator system mounted inside the engine operates both. The actuators of the AMT system are linked to the ECU of

the car. iMT is a clutch-less transmission system, here the driver must manually shift the gears, while the clutch is operated automatically by sensors and software.

Transmission mix trend



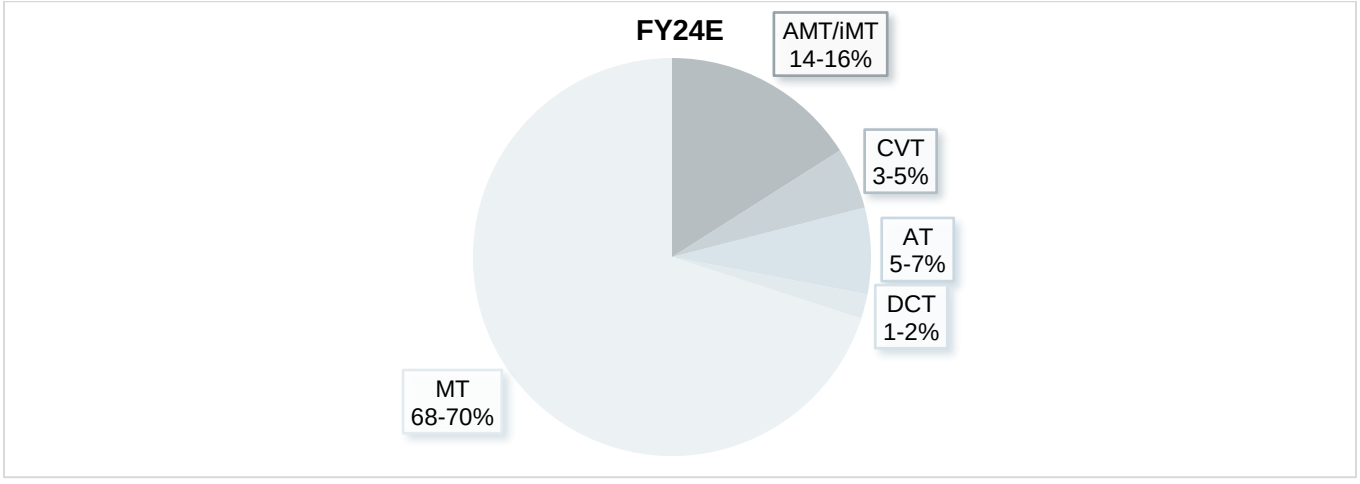
Note: The above split is for only ICE vehicles

Source: Industry, CRISIL Intelligence

PV production is completely dominated by relatively cheaper manual transmission vehicles. However, over the years, automatic transmission has been gaining popularity.

Share of automatic transmission vehicles in domestic PV sales has increased from 8-10% in fiscal 2019 to approximately 30-32% in fiscal 2024. However, domestic PV sector is still dominated by manual transmission system, which accounted for more than 65% of sales in fiscal 2024. Penetration of manual transmission vehicles is still higher owing to dominance of high price consciousness over the need for comfort. However, with worsening traffic conditions, rising affordability, need for comfort and availability of semi-automatic transmission at affordable price points, AMT and iMT started gaining share over the last five years. AMT and iMT together accounted for 14-16% share in sales in fiscal 2024.

Transmission mix



Note: MT – Manual Transmission, AMT – Automatic Manual Transmission, iMT – Intelligent Manual Transmission, AT – Automatic Transmission, DCT – Dual Clutch Transmission, E – Estimated

Source: Industry, CRISIL Intelligence

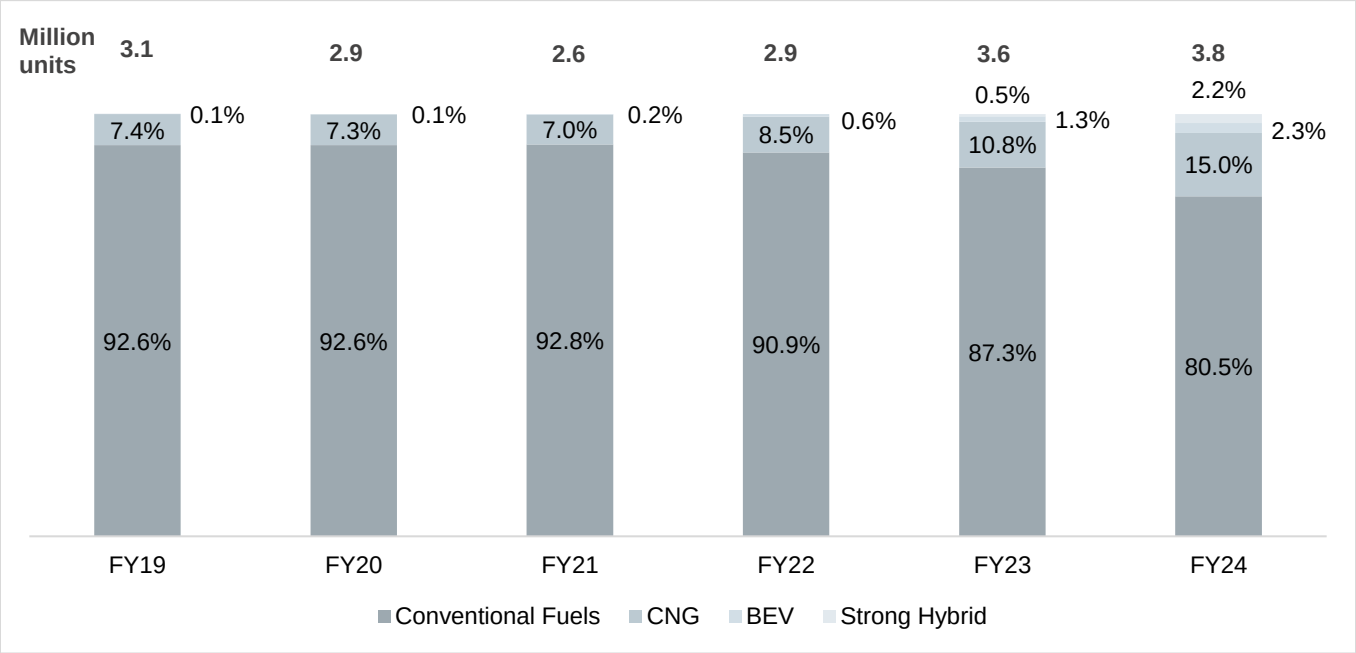
AMT and iMT technologies dominate the affordable vehicles segment (less than Rs 8 lakh). In premium cars, technologies such as AT, CVT and DCT are preferred as they offer smoother driving experience. CRISIL's market checks indicate that AT offers best driving experience but is the costliest among competing technologies. Its penetration is prevalent primarily in premium and luxury passenger vehicles. AT, CVT and DCT approximately accounted for 5-7%, 3-5% and 1-2% of domestic vehicle production in fiscal 2024.

Changing powertrain mix in the Indian PV industry

Conventional fuel powertrains (petrol and diesel) have dominated the Indian PV industry for decades. Petrol vehicles were the preferred choice despite diesel being cheaper than petrol primarily because of their low acquisition cost compared with diesel vehicles. However, the preference for diesel vehicles surged over fiscals 2012 to 2014 due to rising petrol prices and an increase in the price gap with diesel. Further, diesel vehicles offered better mileage and the difference between the acquisition cost of diesel and petrol vehicles was only marginal.

Moreover, a shift in OEM focus from diesel to petrol vehicles including discontinuation of diesel models by a few OEMs such as Maruti with the onset of stricter BSVI norms, exacerbated the situation for diesel vehicles. In fiscal 2024, the share of diesel powertrain in the industry retail slid to only 18%. On the other hand, the share of petrol variants expanded from 56% in fiscal 2019 to 65% by fiscal 2024.

Powetrain mix trend of PV industry retails



Note: Strong hybrid: Vehicles having a combustion engine as well as an electric motor. The vehicle can be powered by the engine or the battery, or by both simultaneously. The battery of the vehicle is charged by the combustion engine and not by an external power source. Telangana & Lakshadweep retail data is not available on VAHAN.

Source: VAHAN, CRISIL Intelligence

Competitive OEM landscape

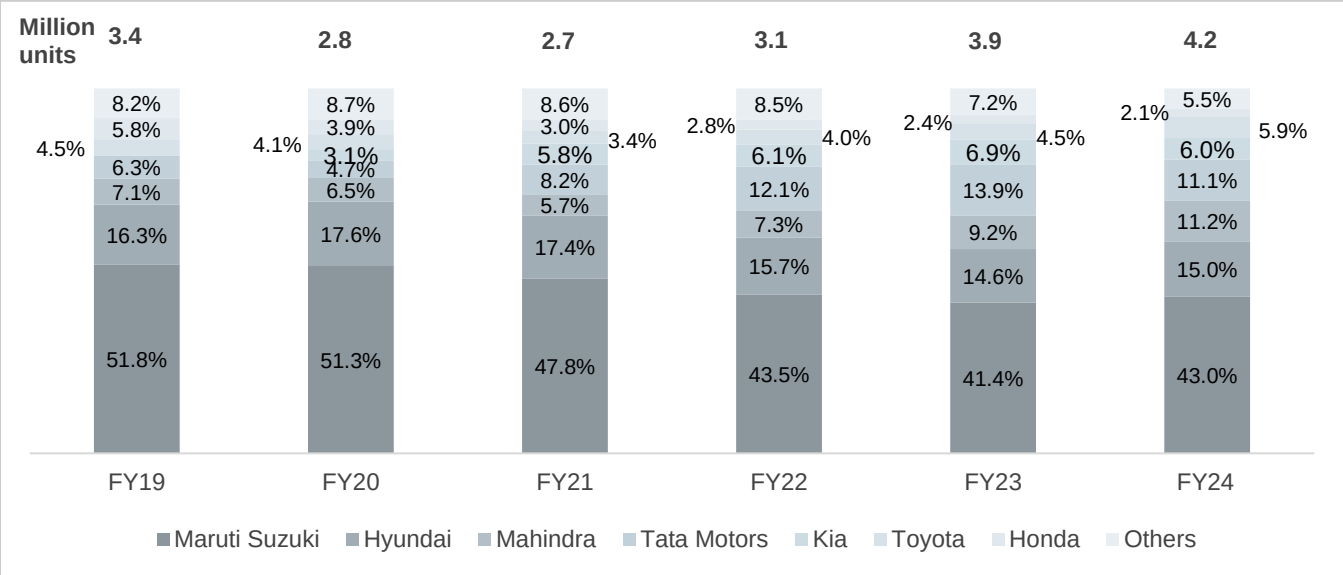
The domestic PV market is oligopolistic with a few players dominating the entire industry. Maruti Suzuki leads the PV industry in terms of domestic sales volumes. Hyundai is the second-largest contributor to domestic sales, closely followed by Tata Motors and Mahindra. These four players together account for ~80% of the market.

However, competition has intensified in the past five years with all players launching competitively priced feature-rich vehicles and recent entrants such as Kia and MG grabbing a sizeable share.

The share of Maruti Suzuki contracted from a high base of 52% in fiscal 2019 to 43% in fiscal 2024 due to a shift in customer preference from hatchbacks towards SUVs and Maruti Suzuki's focus on the cars segment. However, success of recent launches such as Grand Vitara, Fronx, Invicto and continued traction for Ertiga and Brezza helped Maruti Suzuki regain some lost ground in fiscal 2024.

Hyundai is the second-largest contributor to Indian domestic PV sales and has maintained its position in the market due to continued traction of popular SUV models such as Creta and Venue, coupled with intermittent new vehicle launches and upgrades of its popular models. Introduction of Venue, Aura and Kona helped the company expand its market presence in fiscal 2020. In the next four years, Hyundai maintained a 15-18% share within the domestic market amid continued demand aided by intermittent upgrades to its popular models such as i10, i20, Creta, Verna and Venue.

Domestic market share of PVs by OEM



Note: Others include MG, Renault/Nissan, Skoda, PCA. etc, figures above the bars are sales volumes.

Source: Society of Indian Automobile Manufacturers (SIAM), CRISIL Intelligence

Tata Motors gained ground in the past five years riding on the success of SUV models Nexon and Punch. The increased traction for EVs (where the company dominates) has also boosted Tata Motors sales. In turn, Tata Motors' share of total market expanded from 6% to 11% during the fiscal 2019-2024 period.

EV penetration in PVs

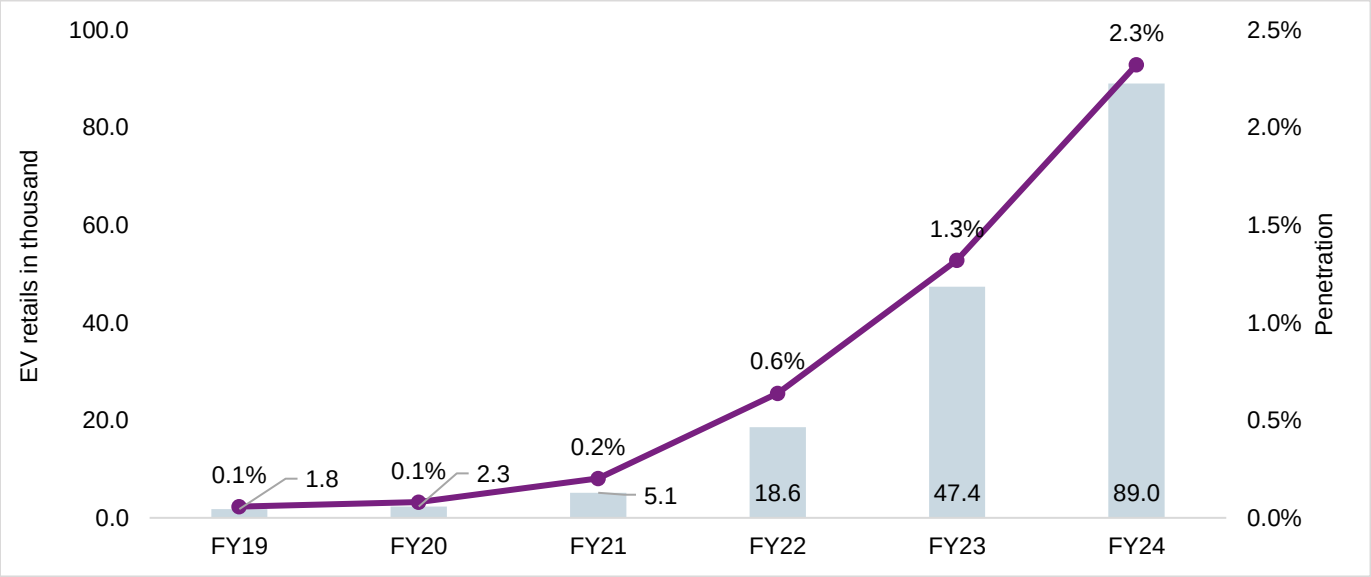
Amid rising environmental concerns, EVs are gaining traction globally, including in India. The country is one of the signatories to the Paris Agreement under the United Nations Framework Convention on Climate Change. It is also part of the EV30@30 campaign, targeting a 30% sales share for EVs by 2030.

To accelerate EV adoption, the government has been incentivising consumers by extending support via Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) subsidy as well as tax cuts. The government announced Rs 100 billion for Phase II of FAME, which commenced on April 1, 2019. The policy aims to provide a subsidy of Rs 10,000 per kWh to four-wheelers (battery EVs, plug-in hybrid EVs, strong hybrids) for commercial purposes and public transport. It also envisions creation of charging infrastructure for EVs.

These schemes, alongside the PLI scheme, scrappage policy as well as the Make in India initiative, are setting up the roadmap for widespread EV manufacturing and adoption (these policies have been covered in detail in earlier sections).

EV retails increased from ~2,000 vehicles in fiscal 2019 to 89,000 vehicles in fiscal 2024: a 45x increase in five years. In turn, the penetration of EVs within the industry retails rose from 0.1% in fiscal 2019 to 2.3% by fiscal 2024.

Domestic EV retail and penetration trend in PVs



Note: VAHAN figures exclude Telangana, Lakshadweep retails

Source: VAHAN, CRISIL Intelligence

Outlook of the domestic passenger vehicle industry (fiscals 2024 to 2029)

CRISIL Intelligence expects the macroeconomic scenario to support to industry growth with GDP projected to grow at a healthy pace between fiscals 2024 and 2029. India's GDP growth is expected to outperform other major geographies over the next five years at 6-8%. Inflation levels are also expected to remain subdued in the 3-5% range, which is within the RBI's target band. CRISIL Intelligence has assumed three years of normal monsoons within the five-year

outlook period and has considered positive momentum in rural demand. Fuel prices are also expected to remain almost steady in the next five years. These favourable macroeconomic factors are expected to support consumer disposable income.

Besides macroeconomic factors, continued government support in terms of policies as well as continued expenditure and investments are expected to boost the industry. The favourable demographics are an added advantage for India and expected to help propel the PV industry.

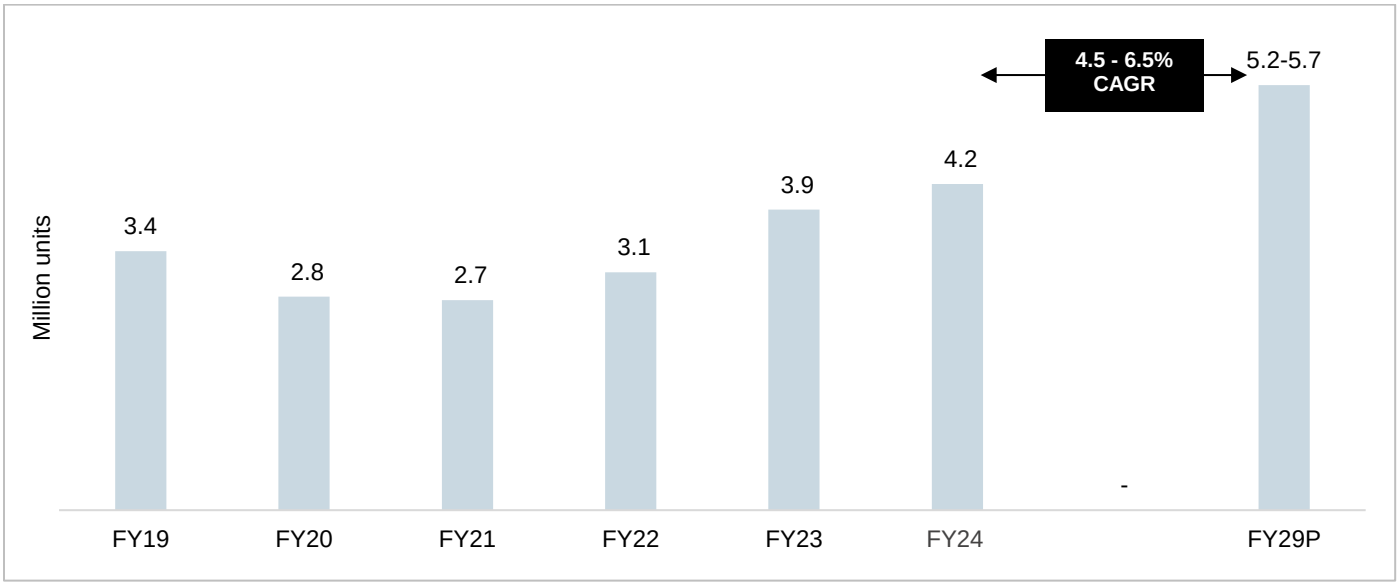
Additionally, OEMs are expected to continue to launch feature-rich competitively priced vehicles, aiding overall demand growth.

The financing scenario is projected to remain favourable for the industry and lend further support amid expanding financing reach and high loan to value (LTV) levels. Moreover, after multiple rate hikes in the past two years, a rate cut of 25-50 bps is expected to keep interest rates competitive in the near term. Given projections of subdued inflation levels in the long term, any further rate hike seems unlikely.

Changing market dynamics, including a younger consumer base, premiumisation, electrification, shorter replacement cycles (four to five years currently vis-a-vis seven to eight years a decade ago) will provide further impetus to demand. Additionally, the government's push for scrapping old vehicles (as per the government regulation vehicles above the age of 15 years will be compulsorily scrapped) is expected to shorten replacement cycles and support demand.

CRISIL Intelligence expects domestic sales to grow at a 4.5-6.5% CAGR between fiscals 2024 and 2029 to 5.2-5.7 million vehicles.

Domestic PV industry outlook (volumes)



Source: SIAM, CRISIL Intelligence

Segmental outlook

Domestic industry growth is expected to be led by SUV and MPV segments, while hatchback, sedan and van segments are expected to clock muted growth.

Rise of SUVs

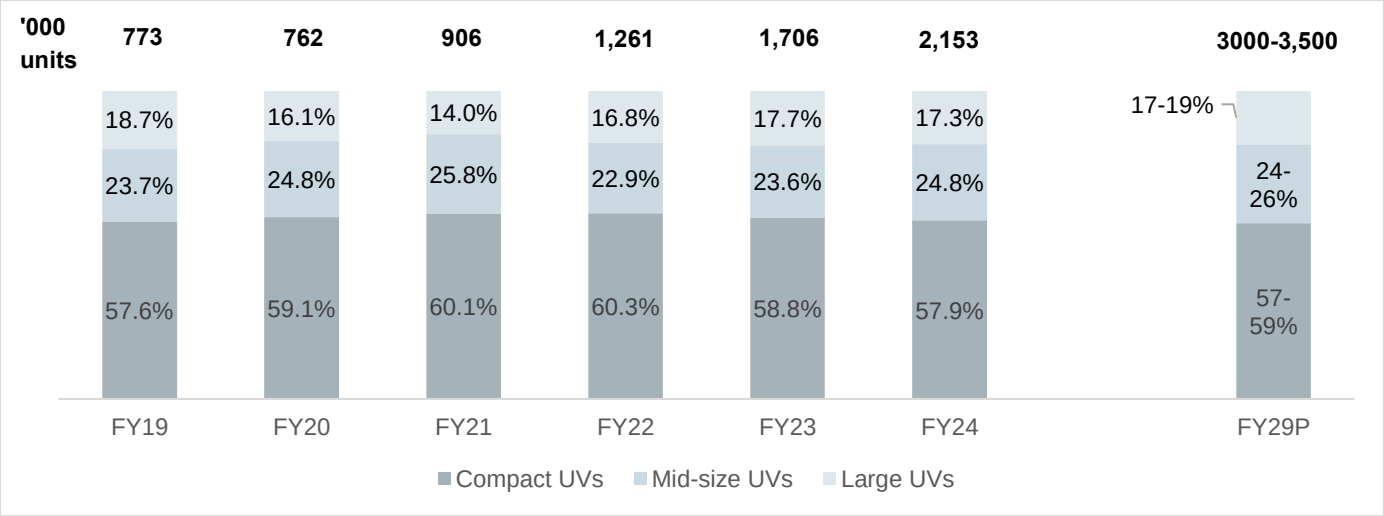
The SUV segment, which traditionally appealed to customers valuing larger seating capacity and its ability to drive on rough terrain, has increasingly gained customer preference over the years. The compact SUV segment, especially, provided the much-desired SUV body styling at competitive rates bringing SUV segment within the reach of the common consumers.

Recognising the changing consumer preferences, OEMs also launched higher number of vehicles in the SUV segment compared to other segments providing a further fillip to the SUV share expansion.

Thus, the changing customer preference coupled with new vehicle launches provided the real thrust to the growth of the SUV segment. Moreover, entry of global players like Kia and MG, with their SUV portfolios lent further support to the segment's growth.

All of this has led to the share of SUVs in overall domestic PV sales to more than double from 23% in fiscal 2019 to 50% in fiscal 2024 from. During the last 5 years, while industry witnessed a growth at 5% CAGR, the SUV segment grew at more than 4x the growth rate of 23% CAGR.

Sub segmental shift within SUV segment



Note: Figures above bars are the sales volumes.
Source: SIAM, CRISIL Intelligence

Within the SUV segment, compact SUVs (length <4m) grew in line (at 23% CAGR) with the overall SUV segment keeping its share steady within the SUV segment.

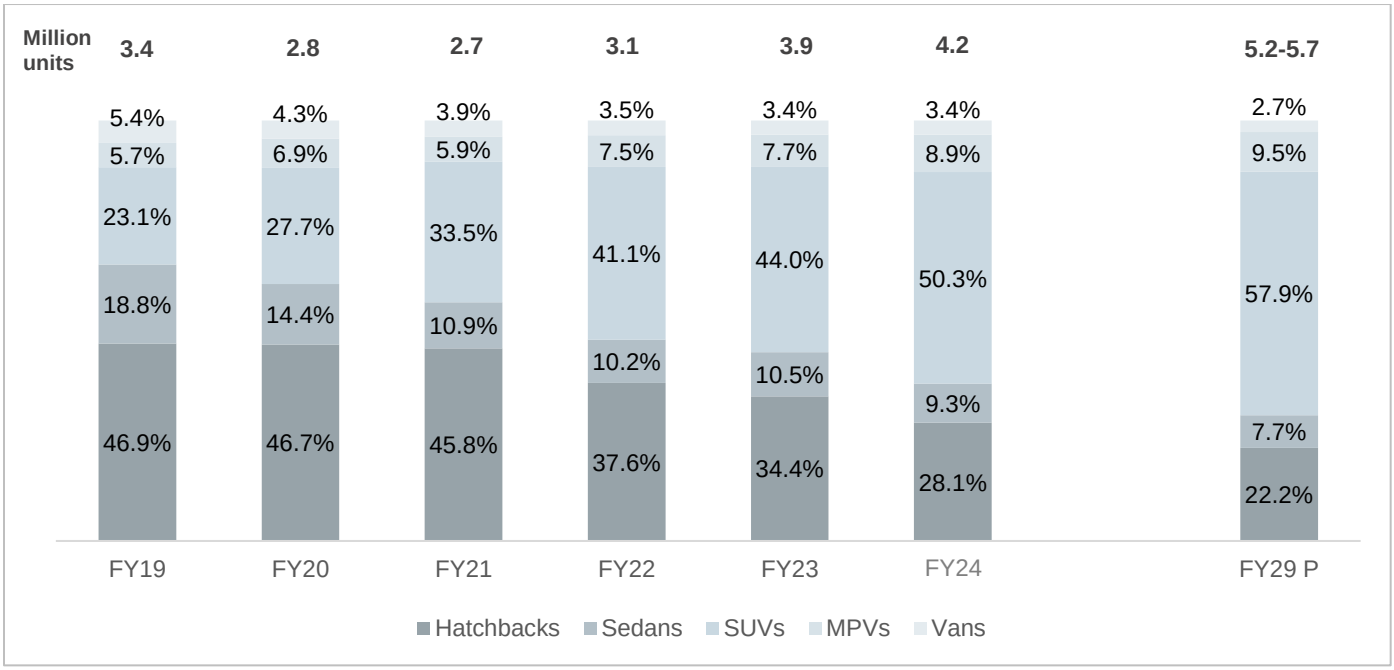
Segmental growth outlook

Segment	FY19-FY24 CAGR	FY24-FY29P CAGR
Hatchbacks	**(6) %**	**0 - 2.0%**
Compact hatchbacks	(8) %	(1) -0.5%
Premium hatchbacks	0%	1.5 - 4.0%

Sedans	**(9) %**	**0.5 - 2.0%**
SUVs	**23%**	**7.0 – 9.0%**
Compact SUVs	23%	6.8 - 8.8%
Mid-size SUVs	24%	7.8 – 10.0%
Large SUVs	21%	7.2 – 9.2%
MPVs	**14%**	**6.4 - 9.4%**
Vans	**(5) %**	**1.1- 2.0%**
Total	**5%**	**4.5 – 6.5%**

Source: SIAM, CRISIL Intelligence

Outlook by industry segment



Source: SIAM, CRISIL Intelligence

Estimated penetration of electric PVs by segment by fiscal 2029

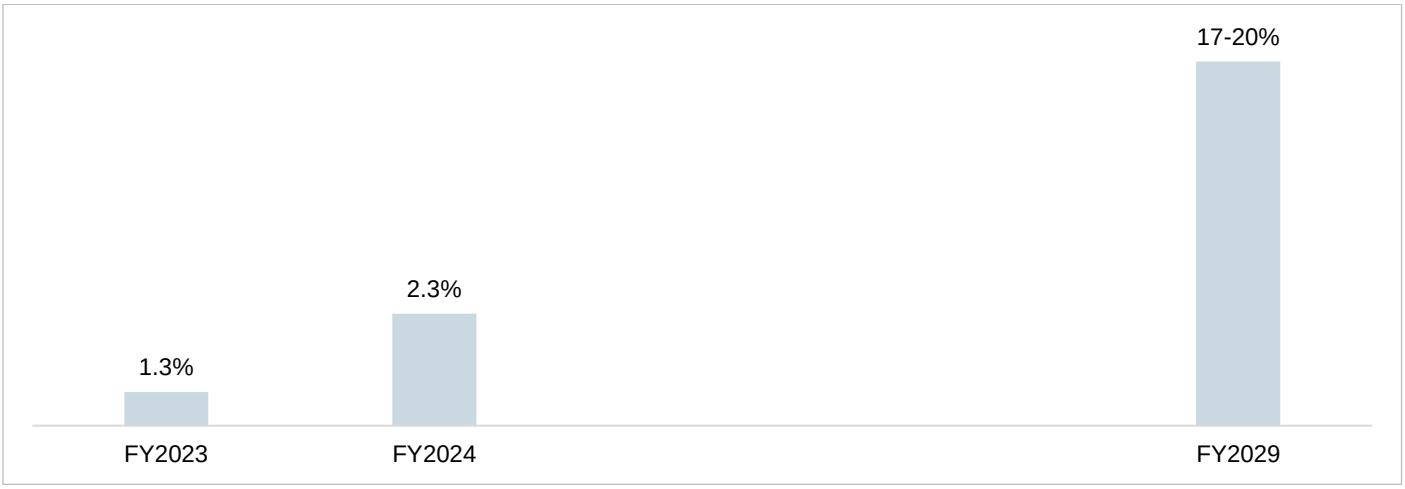
CRISIL Intelligence believes that lack of charging infrastructure, range anxiety and lack of large OEM presence is hindering EV adoption in India. The taxi segment accounts for 10-15% of sales within passenger cars, Within the taxi segment, cab aggregators are expected to lead EV adoption, resulting in an estimated adoption of 25-31% within this segment by fiscal 2027 (considering that adequate infrastructure is available by then).

The TOA and TCO of electric personal cars are still higher compared with the petrol alternative due to their lower running costs. Therefore, EVs are currently not a viable use-case. However, the gap is expected to shrink in fiscal 2029, driving EV adoption in the personal usage segment. In addition, availability of charging infrastructure and range, especially for intercity travel, are likely to be key deciding factors for EV adoption in the personal car segment.

Hence, CRISIL Intelligence expects the share of EVs in total passenger car sales to grow to 17-20% in fiscal 2029 from 2.3% in fiscal 2024.

EV penetration could be higher if the government adopts stricter policies on OEMs for not meeting CAFÉ norms. The exact quantum of EV penetration in an aggressive case depends on incentives given for adoption and setting up of charging infrastructure.

EV penetration outlook for PVs



Source: CRISIL Intelligence

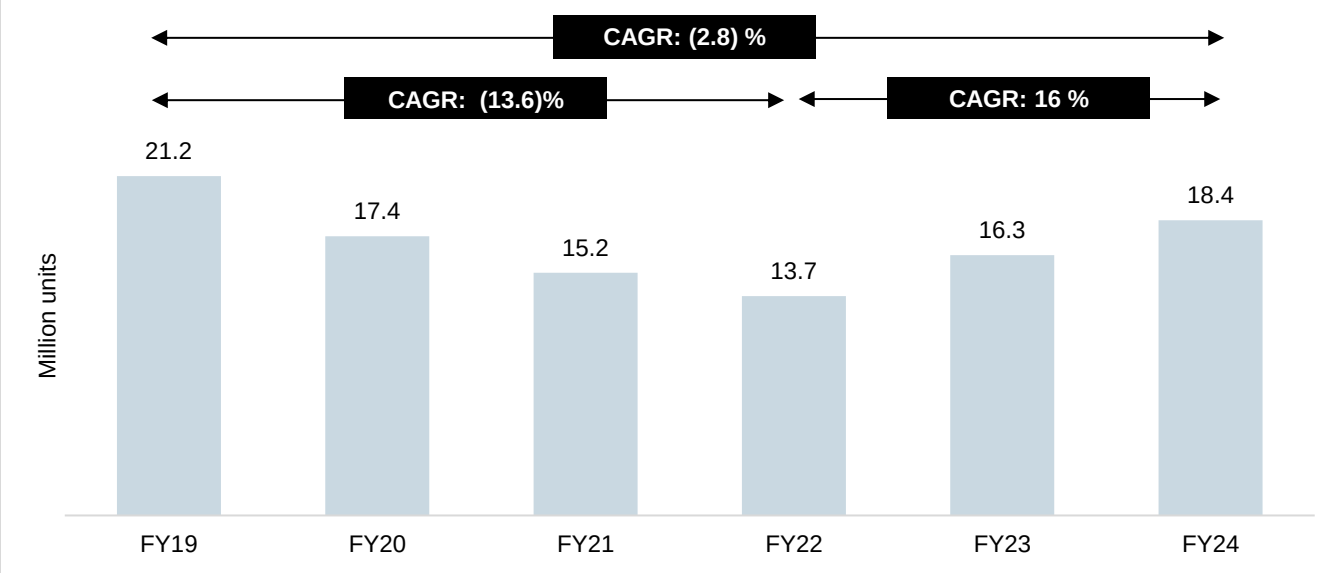
Indian two-wheeler industry

Review of the domestic two-wheeler industry (fiscals 2019 to 2024)

India is the largest motorised two-wheeler market in the world by volume, with domestic sales of 18.4 million units in fiscal 2024. Two-wheeler sales constituted 73% of the total automobile market, which includes two-wheelers, three-wheelers, passenger vehicles (PVs), commercial vehicles (CVs) and tractors by volume in fiscal 2024. The passenger vehicle segment contributed about 16.7% to the Indian automobile industry, while CVs contributed about 3.8% with three-wheelers and tractors contributing 3.5% and 3% respectively.

From fiscal 2019 to fiscal 2022, the industry witnessed a contraction at a CAGR of 13.6% as the pandemic, nationwide lockdowns, reduced mobility, unfavourable macroeconomic scenario, closure of schools, colleges and offices, and work from home impacted the demand for two-wheelers.

Domestic two-wheeler sales volume trend – fiscals 2019 to fiscals 2024



Note: Figures in bracket to be read as negative (E.g. (10) to be read as minus 10), data for ICE and EVs; EV retail data from VAHAN have been considered.

Source: SIAM, VAHAN, CRISIL Intelligence

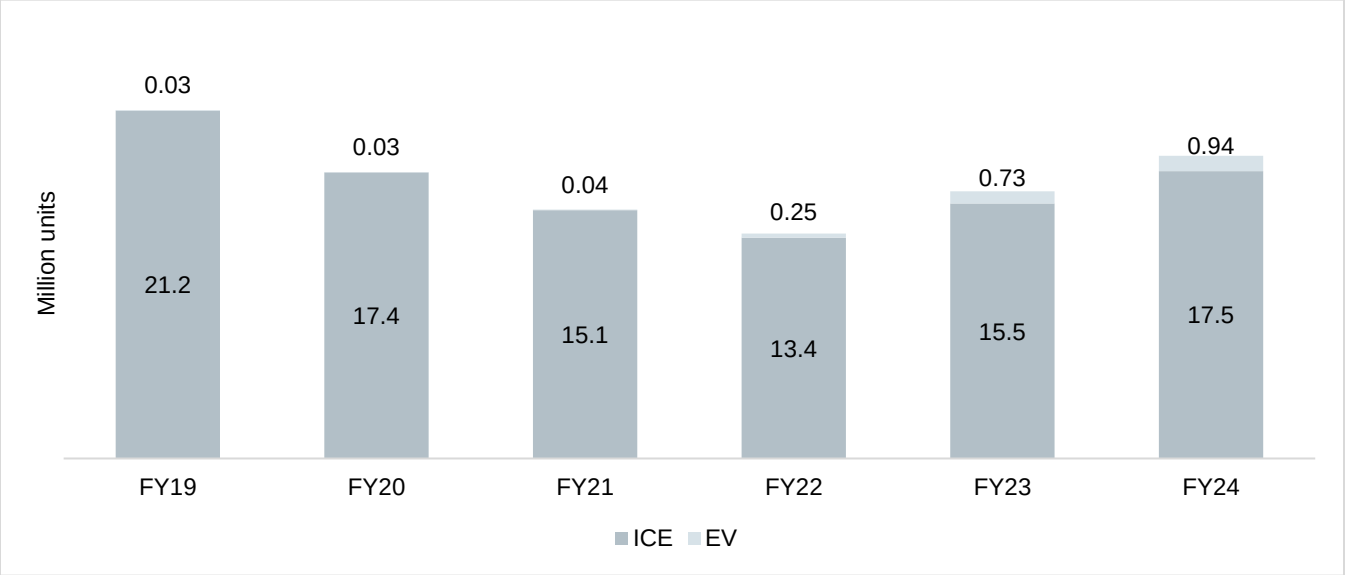
From the reduced base of fiscal 2022, two-wheeler sales rebounded in fiscal 2023 and recorded a healthy growth of 19%, driven by improving demand sentiments and the normalisation of economic activities and increased mobility. The pent-up demand due to the postponement during the pandemic period and a sharp rise in scooters demand with restarting of colleges and offices provided a boost to the industry demand. Despite the normalisation of public transport, improved frequency of intracity bus and railway services, the demand for the last mile mobility, and in turn the demand for two-wheelers remained buoyant during the year.

In addition, the retail sales of the two-wheeler segment almost tripled during the year, providing an additional boost to the overall sales in fiscal 2023.

However, the higher interest outgo with increased repo rates and further increase in vehicle prices restricted the growth of the two-wheeler industry sales in fiscal 2023.

In fiscal 2024, the two-wheeler industry's sales grew by a further 13%, supported by further improvement in the macroeconomic scenario, rural support, continued traction for premium motorcycles as well as scooters. In addition, continued demand for electric two-wheelers despite the subsidy cut[1] supported the growth in fiscal 2024. The new launches, especially in the premium segments provided an added support to the demand. The commuter motorcycle segment also witnessed some improvement during the year after consecutive contractions aided by limited rise in operating costs as well as increased customer incentives.

Domestic two-wheeler sales volume trend (ICE vs EV)



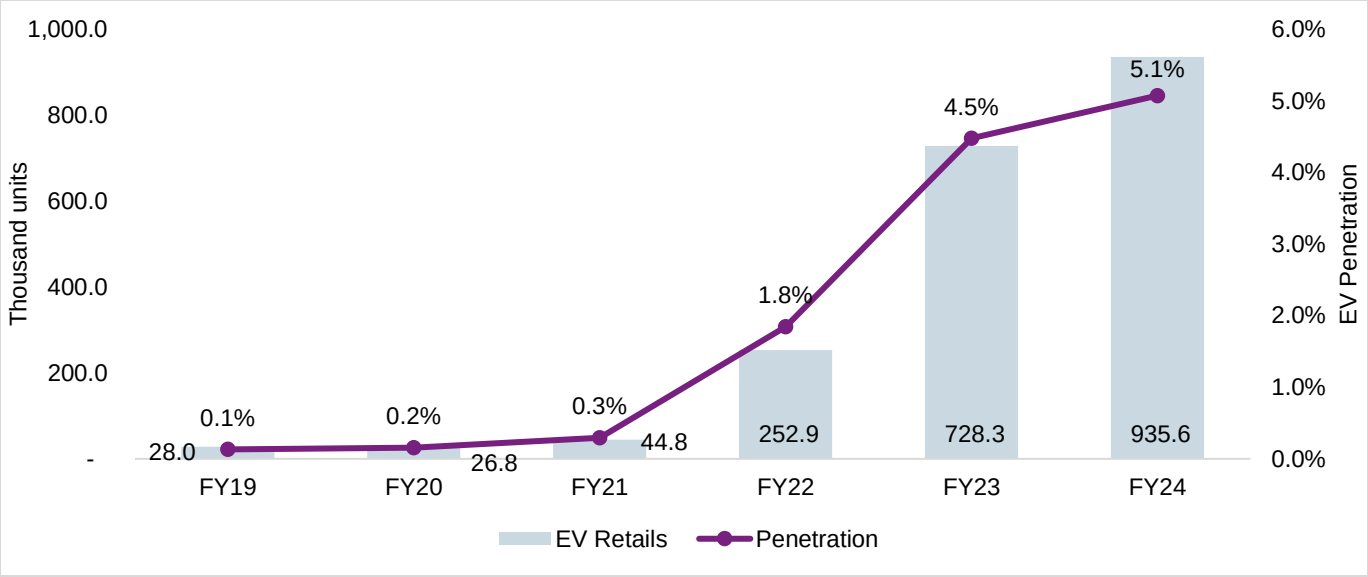
Source: SIAM, VAHAN, CRISIL Intelligence

y-o-y growth	FY19	FY20	FY21	FY22	FY23	FY24	FY19-24 CAGR
ICE	5%	-18%	-13%	-11%	16%	13%	-4%
EV	1394%	-4%	67%	464%	188%	29%	102%

Source: SIAM, VAHAN, CRISIL Intelligence

[1] *The Ministry of Heavy Industries (MHI) had decided to slash the FAME II subsidy of electric two-wheelers (effective from June 2023) to Rs 10,000 per Kwh from the Rs 15,000 per Kwh. Apart from reducing the per Kwh incentive by Rs 5,000, the ministry also reduced the maximum subsidy cap of 40 per cent of the ex-factory price of the vehicle to 15 per cent.*

E-2W Retails and Penetration trend – fiscals 2019 to 2024



Note: Only high-speed electric two wheelers have been considered for the analysis
Source: SIAM, SMEV, VAHAN, CRISIL Intelligence

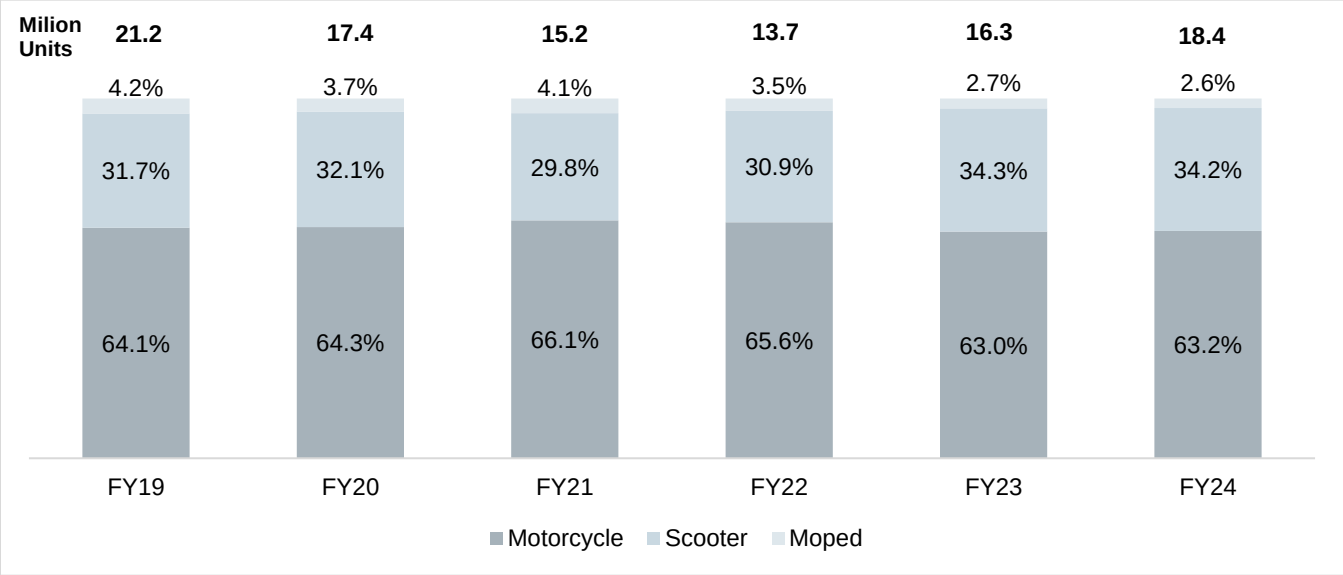
Over the past five years, the electrification within the industry has provided a boost to the industry sales. During these years (since FY19), when the ICE vehicle sales declined, the sharp rise in EV retails restricted the drop in industry sales volumes. From fiscal 2019 to fiscal 2024, the ICE segment contracted at a CAGR of 3.7% and EV retails skyrocketed at a CAGR of 101.7%, albeit from a lower base, which arrested the drop in the industry sales.

Segment wise domestic sales trend

Motorcycles dominate the domestic two-wheeler industry sales with more than 60% contribution to the annual domestic sales. However, their contribution has gradually contracted over the years, from 78% in fiscal 2009 to 63% in fiscal 2024.

On the other hand, the scooter segment expanded its presence over the long-term horizon, from 15% in fiscal 2009 to 34% in fiscal 2024. The moped segment also lost some ground to scooters over the years, from around 6% share in fiscal 2009 to ~3% in fiscal 2024.

Domestic two-wheeler sales segmental trend – fiscals 2019 to 2024



Note: Data includes ICE and EVs; EV retail data from VAHAN have been considered.

Source: SIAM, VAHAN, CRISIL Intelligence

CAGR for Domestic two-wheeler sales segmental trend – fiscals 2019 to 2024

y-o-y growth	Motorcycle	Scooter	Moped
FY19-24 CAGR	-3.0%	-4.3%	-11.4%

Note: Data includes ICE and EVs; EV retail data from VAHAN have been considered.

Source: SIAM, VAHAN, CRISIL Intelligence

Scooters

Over the past five years, the share of scooters increased from 31.7% in fiscal 2019 to 34.2% in fiscal 2024. The share of the scooter segment increased on the back of strong demand from new model launches (such as the Dio 125, Avenis, upgrades of Activa, Jupiter as well as e-scooters), increasing use of scooters by working women in urban areas (due to high convenience) and a growing preference as a second vehicle in households. There has been an increase in multiple vehicle ownership, including a passenger vehicle, and multiple two-wheelers in a single family, driving demand.

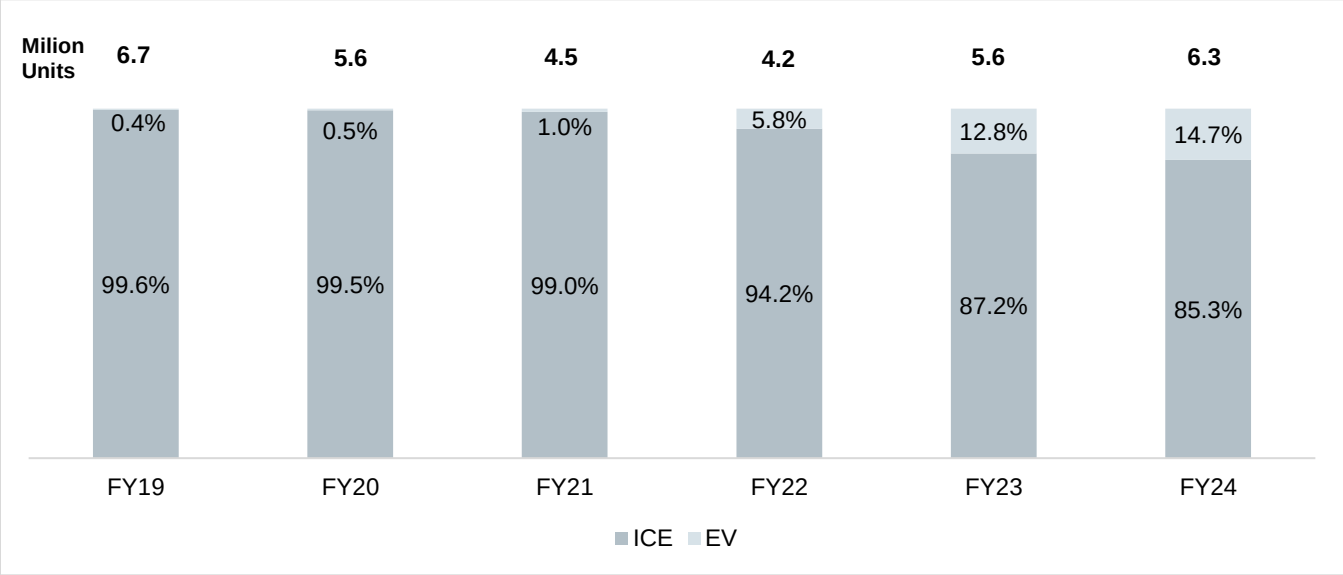
The scooter also gained acceptance in rural areas as road penetration increased and it became a utility vehicle. Earlier, the scooter was positioned primarily as an urban vehicle. Now, it has gradually evolved to become a preferred means of commuting for women in rural areas as well.

During the industry slowdown from fiscal 2019 to fiscal 2024, the overall scooter segment contracted at the slowest pace of 1.3% CAGR, compared with 3% CAGR contraction for motorcycles and 11.4% CAGR contraction for mopeds. A sharp rise in e-scooter sales and new model launches, especially in the premium (=> 125cc) scooter segment restricted the drop in scooter sales.

During the pandemic, the reduced need for mobility due to lockdowns, closure of schools/ colleges and offices impacted the scooter demand significantly. Sales of scooters (ICE+ EV) witnessed a sharp drop of 19% in fiscal 2021 and a further drop of 6% in fiscal 2022. However, scooter sales rebounded in fiscal 2023, led by the reopening of

offices, schools and colleges. The pent up demand from the past two years provided a boost to the sales of scooters. In addition, the increased retails of e-scooters also gave an additional boost to the scooter sales. The scooter segment grew at a faster pace of 32% year-on-year, compared with 14% growth witnessed in motorcycles, thus backing the share expansion of scooters in fiscal 2023. In fiscal 2024, both motorcycles and scooters increased at a healthy pace of around 14% keeping the share near steady.

ICE vs EV split within domestic scooter sales – fiscals 2019 to 2024



Note: EV retail data from VAHAN have been considered.

Source: SIAM, VAHAN, CRISIL Intelligence

Within the scooter segment, EV scooters witnessed growth at an accelerated pace and contributed a sizeable share of 14.7% to the overall scooter sales in fiscal 2024. The launch of new models, government incentives, rising awareness, increased acquisition and operating costs of the ICE equivalents gave a boost to the EV sales during fiscal 2019-2024. The EV scooters clocked a CAGR of 101% in the past five years, and their penetration within the scooter segment rose from 0.4% in fiscal 2019 to 14.7% in fiscal 2024.

In contrast, the premium scooter (=>125 cc) segment, clocked a 12% CAGR over the period, albeit from a smaller base. A relatively price agnostic customer base, feature-rich attractively designed vehicles, young buyers who prefer high performance and advanced features, auto OEM focus, multiple vehicle launches and premiumisation trend aided the growth of this segment. The share of premium scooters in the ICE scooter segment rose from about 20% in fiscal 2019 and to 47% in fiscal 2024.

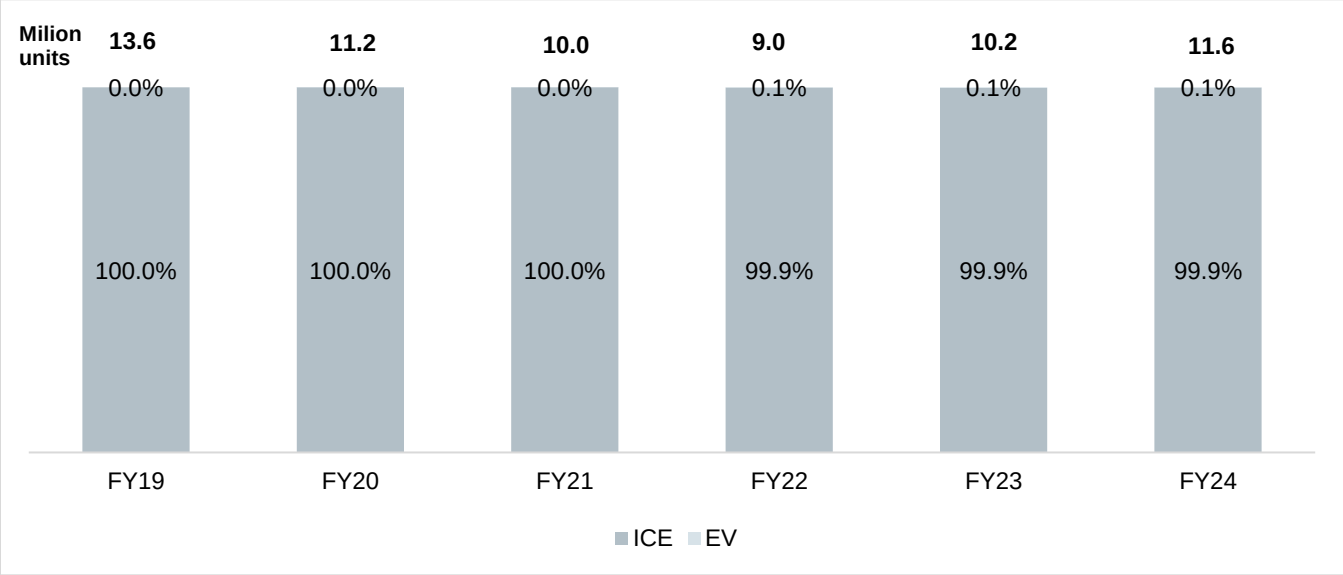
Motorcycles

In the overall domestic sales, motorcycles have maintained their leading position in the past five years, but lost some ground to scooters in the same period. During the pandemic (fiscal 2021 and fiscal 2022), the reduced requirement of scooters and the continued requirement of motorcycles, especially for daily commuting in the absence of public transport, supported the demand for motorcycles and limited their decline.

During the pandemic, the availability of public transportation was limited, even the shared mobility options, including office buses and taxis were restricted making personal vehicles, including motorcycles, the primary option for daily

commute, especially for the blue-collar workers and rural customer base. Relatively prosperous customers, women commuters especially from urban background took advantage of the work-from-home option or their four-wheeled vehicles limiting the need for scooters during this period. This aided the moderate market share expansion during fiscal 2021. Post pandemic, improving mobility and gradual rise in demand for scooters caused the share of motorcycles to contract in the next three fiscals, reaching 63% by fiscal 2024.

ICE vs EV split within domestic motorcycles sales – fiscals 2019-2024



Note: EV retail data from VAHAN have been considered.

Source: SIAM, VAHAN, CRISIL Intelligence

Unlike scooters, the EV penetration within motorcycles has remained insignificant due to a lack of EV options. A few OEMs, such as Revolt, offered EV motorcycles from fiscal 2020. Manufacturers such as Tork and Ultraviolette also introduced their e-bikes/ motorcycles in the next two to three years. However, given the limited vehicle options, even in the premium motorcycles category, higher acquisition costs, larger range anxiety concern due to higher daily running for motorcycles; the adoption of EVs within motorcycles was only gradual and reached only 0.1% of overall motorcycle sales by fiscal 2024. Moreover, the ICE variants continue to dominate the motorcycle sales. However, even within the ICE motorcycles, the premium motorcycle segment (=>125 cc) has witnessed a CAGR of 3% during fiscal 2019-2024 period while the commuter motorcycle segment (<=110 cc) contracted at a rapid pace of 8% CAGR.

On the other hand, the premium motorcycle segment logged a CAGR of 3%, backed by lower impact of the pandemic on the financially stable customer base, higher OEM focus with increased vehicle launches, feature-rich and attractive vehicle introductions, and entry of global players such as Harley, and Triumph with India-focussed models into the premium motorcycle segment. High performance tech-enabled vehicles see higher acceptance among the rising younger buyer base who view vehicle as an extension of their personality. Thus, the share of premium motorcycles, within the ICE motorcycles, increased from 38% in fiscal 2019 to 52% in fiscal 2024.

Segmental growth within the industry in the past five years

Segment	FY19-FY24 CAGR	FY19 share	FY24 share
Motorcycles	**(3.0) %**	**64.1%**	**63.2%**

ICE	(3.1) %	64.1%	63.1%
EV	NM	0.0%	0.1%
Scooters	**(1.3) %**	**31.7%**	**34.2%**
ICE	(4.3) %	31.6%	29.2%
EV	101.3%	0.1%	5.0%
Mopeds	**(11.4) %**	**4.2%**	**2.6%**
Total	**(2.8) %**	**100%**	**100%**

Note: NM: Not meaningful; Figures in bracket to be read as negative (Eg. (10) to be read as minus 10), EV retail data from VAHAN have been considered.

Source: SIAM, CRISIL Intelligence

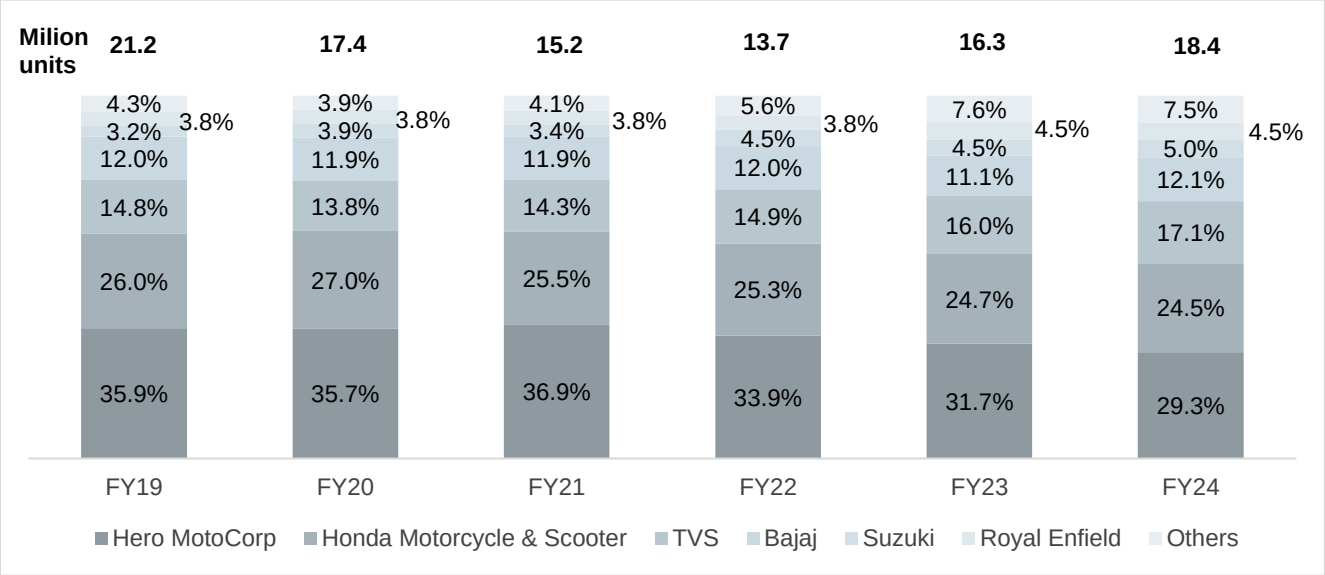
The smallest segment of mopeds witnessed a contraction during fiscal 2019-2024, amid the increasing adoption of scooters in the semi-urban and rural markets — historically major markets for the moped —led to a loss of market share for mopeds. Limited product portfolio and no new launches also impacted the sales of this segment. Moreover, the pressure on the income of the bottom of the pyramid customer base of mopeds as well as increased operating expenses due to increased fuel costs, higher interest outgo; demand for the segment got impacted. As a result, the share of mopeds dropped from 4.2% in fiscal 2019 to 2.6% in fiscal 2024.

Competitive landscape of the domestic two-wheeler industry

India's two-wheeler industry is an oligopolistic market with the top four players contributing more than 80% of the annual sales. However, over the years, the competition has intensified within the industry, especially, with the entry of new age startups such as Ola, Ather, and Okinawa, catering to the fast-expanding segment of EVs. In fact, the contribution of the top four OEMs has decreased from 89% in fiscal 2019 to 83% in fiscal 2024.

Hero MotoCorp (HMCL) continues to lead the market, although HMCL's contribution has declined from ~36% in fiscal 2019 to 29.3% in fiscal 2024. The increased traction for scooters, including e-scooters as well as premium motorcycles, coupled with pressure on commuter motorcycles sales – where HMCL dominates – have impacted its share. The second largest contributor, Honda Motorcycle & Scooter (HMSI), has also lost some ground to other players, especially the e-scooter manufacturers.

OEM wise contribution to overall two-wheeler domestic sales – fiscals 2019 to 2024



Note: Data includes ICE and EVs; EV retail data from VAHAN have been considered.

Source: SIAM, VAHAN, CRISIL Intelligence

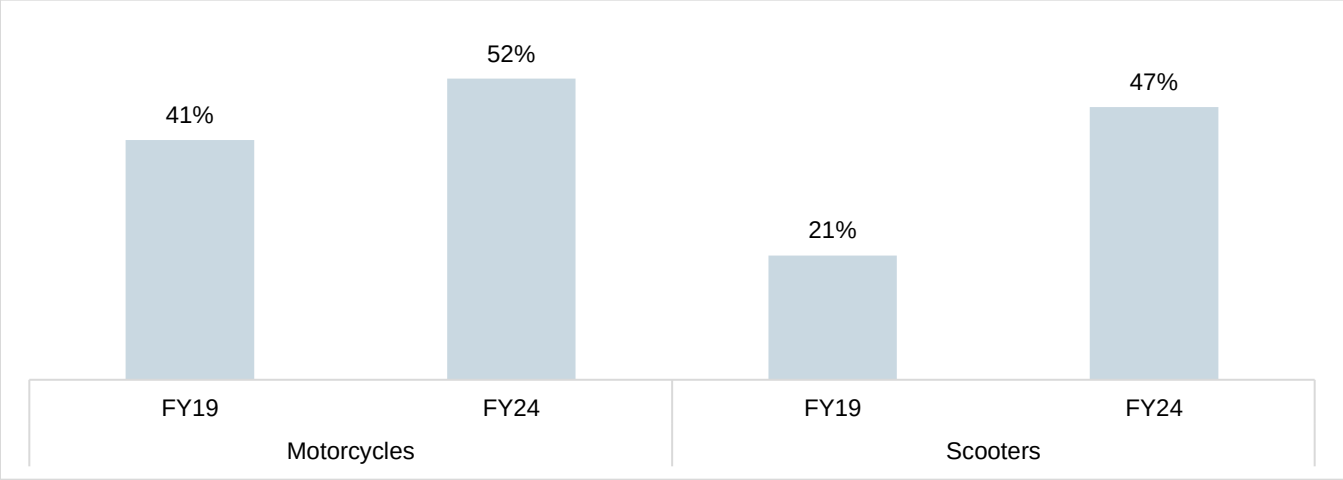
Premiumisation in the industry

A clear shift towards premium vehicles is visible in the two-wheeler industry. Customers are looking to upgrade to the next premium vehicle segment in both motorcycle and scooter segments. The premiumisation trend is supported by various factors such as younger profile of buyers, attractive feature-rich new vehicle launches at competitive rates, vehicles being seen as an extension of a customer's personality, easier access to finance and more launches in the premium segment.

Over fiscals 2019-2024, the share of premium vehicles (=>125cc) in motorcycle sales increased significantly from 41% to 52% and in scooter sales from 21% to 47%. Despite the commuter motorcycles and basic 110 cc scooters segments witnessing a sharp contraction, traction in premium motorcycles and scooters restricted the fall in overall sales. In the last five years, the premium segments have primarily provided the thrust to the industry.

In the long term, CRISIL Intelligence expects the premiumisation trend to support the overall industry growth and support the sales.

Share of premium two-wheelers



Note: Premium motorcycles/ scooters: => 125 cc vehicles

Source: SIAM, CRISIL Intelligence

Electrification in the two-wheeler segment

Over the years, there has been a significant advancement in vehicle technology. Various new features have been added in internal combustion engines (“ICE”) and electric vehicles (“EV”), making them more appealing to the customers, especially the younger buyers. The EV segment has revolutionised the industry in terms of latest technological designs and offerings and ICE vehicles are following with notable advancements. The new-age vehicles offer a wide range of features and innovations to ensure safer, more efficient and environmentally friendly transportation and that cater to varied consumer needs.

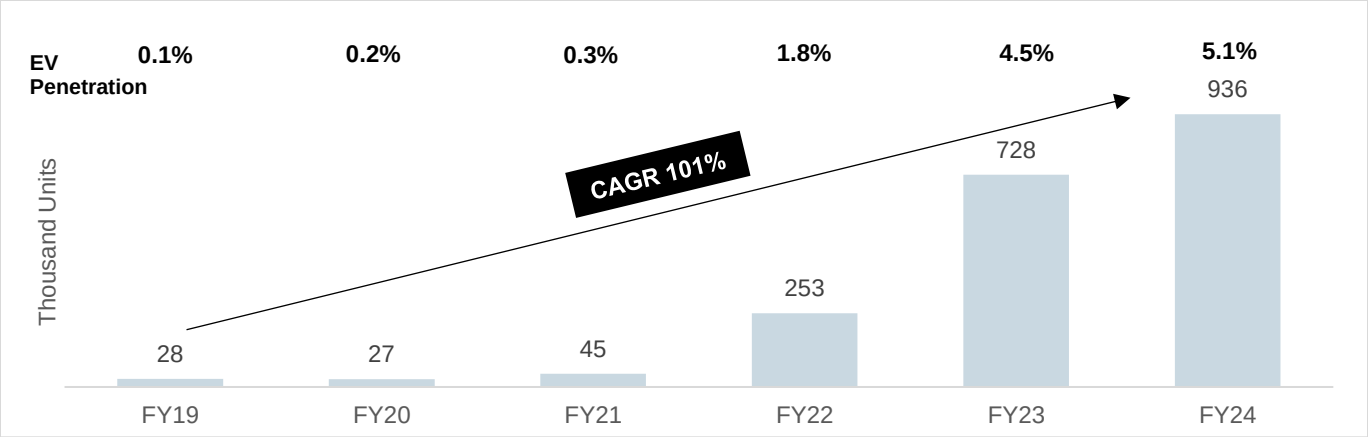
Usage of EVs has increased globally because of the need to curb pollution. In India, too, EVs are gaining popularity, as the government is extending support via Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME II), a policy that encourages the use of electric vehicles and reduce the use of fossil fuel-powered vehicles and tax rate cuts to encourage EV adoption. Further, growing awareness and concerns about environmental issues are likely to drive electrification in India.

EV sales have skyrocketed, especially post the pandemic, aided by the rising awareness, government support and expanding EV portfolio of the industry. The entry of the new age non-traditional OEMs such as Ola, Ather and Okinawa provided an additional boost to the EV segment in India.

While the ICE two-wheeler sales contracted at 3.7% CAGR between fiscals 2019 and 2024, EV sales logged 101% CAGR, thus restricting the drop in overall industry sales.

Even going ahead, the furthering electrification is estimated to provide the much-needed thrust to the industry growth over the long-term horizon. EVs have been covered in detail in the next chapter.

Electric two-wheelers sales trend over fiscals 2019-2024



Note: VAHAN data does not include Telangana & Lakshadweep retails

Source: VAHAN, CRISIL Intelligence

Electric two-wheeler retails were growing only at a moderate pace until fiscal 2022 owing to limited vehicle portfolio, lower awareness, customer concerns regarding the range and inadequate charging infrastructure, despite the Rs 10,000 per kWh government incentive under the FAME scheme. In June 2021, demand incentive for two-wheelers was increased to Rs 15,000/ kWh. Further, expansion in vehicle portfolio and entry of Ola provided an additional thrust to the electric two-wheeler sales in fiscal 2022.

Thus, the increased subsidy on electric two-wheelers, vehicle portfolio expansion and increased acquisition and operating costs of ICE two-wheelers led to the sharp growth in electric two-wheeler retails during fiscal 2022 to ~253,000, up 5.6x from 45,000 in fiscal 2021.

Growth momentum continued for the segment in fiscal 2023, when a sharp push from new age players such as Ola and Ather supported the growth. Legacy OEMs, especially TVS, scaled up their EV production, providing an impetus to the EV sales during the year.

Fiscal 2024 began on a very strong note. However, on June 1, the government reduced the FAME subsidy incentive cap from 40% of a vehicle's value to 15% and capped the subsidy at Rs 10,000 per kWh of battery from Rs 15,000. Owing to this, manufacturers have had to increase the prices of electric scooters, which led to a 57% sequential slowdown in sales in June. This sharp sequential contraction was on an elevated base of May 2023, where customers had pre-bought significantly owing to the price rise from June.

R&D support

The customer base of the two-wheeler industry has shifted towards the young, tech savvy gen Z customers, who prefer the latest state-of-the-art features, attractive designs and colours, connected technology and hi-tech accessories for their new vehicles. This customer base sees vehicles as an extension of their personality.

Moreover, as the replacement cycles have shortened, the intermittent new vehicle launches are a must to ensure continued demand.

Thus, all the OEMs spend a notable amount on research and development (R&D) to integrate the latest tech, design and features for the upcoming models. R&D has also become a necessity to analyse the safety of the two-wheeler riders.

In the last six years, the two-wheeler OEMs have spent ~2% of their annual operating incomes on R&D.

Outlook of the domestic two-wheeler industry (fiscals 2025 to 2029)

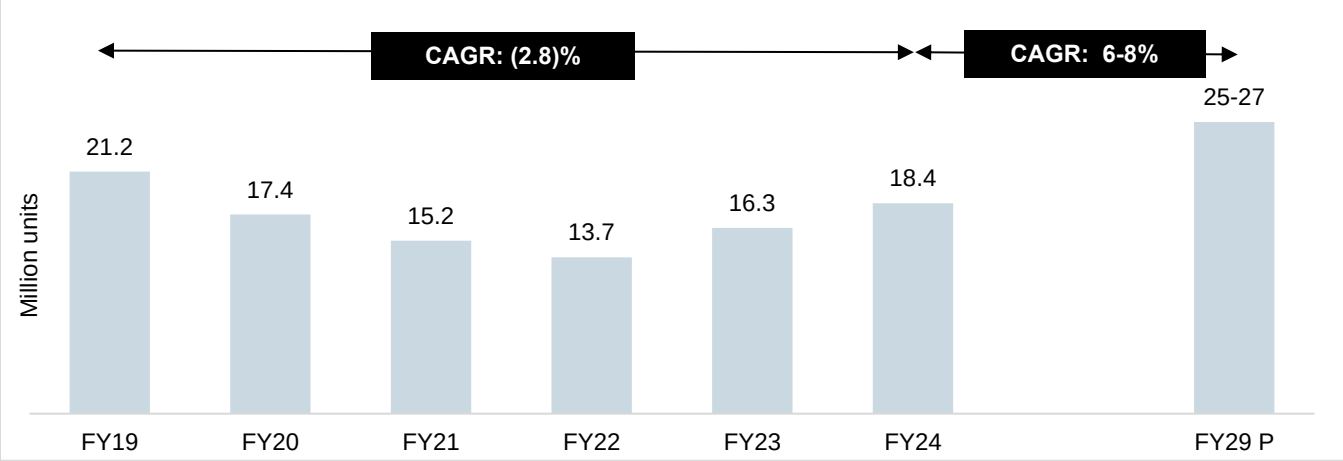
The industry is expected to continue its growth momentum over the long-term horizon led by the positive microeconomic and macroeconomic environment, favourable rural demand, premiumization, intermittent launches, shrinking replacement cycle and continued support from financers. Moreover, continued R&D investments by the OEMs and the technological advancements in the industry to provide an added support to the growth of the industry over the long-term horizon.

Additionally, the fast-rising EV segment, with EV portfolio expansion by legacy players, capacity expansion by new age players will accelerate the industry growth.

Introduction of CNG powertrain, which will offer lower operating costs compared to petrol variants, will push the two-wheeler industry growth further.

Led by these positive industry drivers, two-wheeler industry sales are projected to log 6-8% CAGR and reach volume of 25-27 million by fiscal 2029.

Domestic two-wheeler industry outlook until fiscal 2029

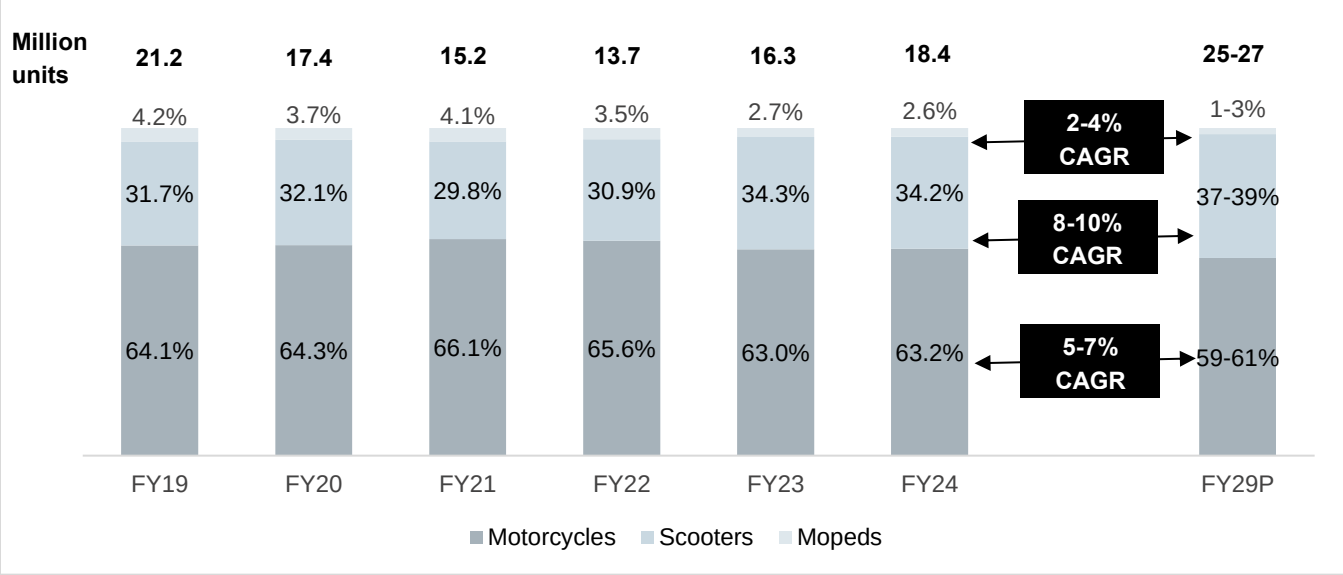


Source: SIAM, CRISIL Intelligence

Going ahead, over the long term horizon, CRISIL Intelligence expects the scooter segment to grow at a much faster pace off the relatively lower base, backed by expected sharp rise in E scooter demand, ubiquitous usage of scooters, rising share of women in workforce, projected growth of e commerce segment coupled with continued focus of OEMs on the scooters segment. The strong launch pipeline, especially for e scooters and faster replacement cycles of the scooters segment will also back the faster growth of the scooters segment. Further, the improvement in supporting charging infrastructure is expected to provide added impetus to the segment's growth.

CRISIL Intelligence projects the scooters segment to grow at a faster pace of 8-10% CAGR over the long-term horizon. However, the ICE scooters segment is expected to contract amidst the shift towards the EV segment. Sizeable portion of the ICE scooter replacement demand will shift towards the electric variants.

Segmental Split Outlook



Source: SIAM, CRISIL Intelligence

Motorcycles, on the other hand, are projected to clock a slower 5-7% CAGR during the period. The premium motorcycles sub-segment is expected to continue to provide the thrust to the motorcycles segment while the commuter segment is projected to grow only moderately.

Premiumisation and upgradation will limit the growth of commuter motorcycles sub-segment. Shifting customer preference towards premium segments supplemented by OEM focus and more launches in the premium segment will provide the thrust to the premium segment going ahead.

The moped segment is expected to grow almost in line with the overall industry growth led by the electrification in the price sensitive segment. Electrification within the mopeds segment will lead the growth of this segment. CRISIL Intelligence expects the relatively financially weak, bottom-of-the-pyramid customer base of mopeds to opt for EV mopeds which have relatively lower acquisition costs.

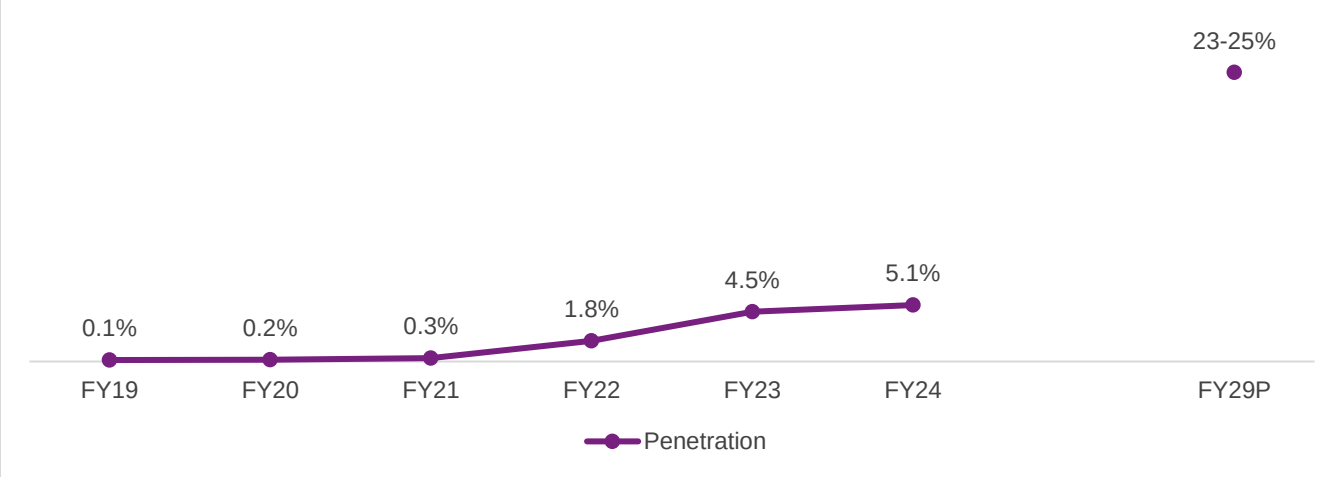
At present, there is only one model, the recently launched E luna, in the mopeds segment. However, more models are expected to be launched in the short term, which will revive the growth of this contracting segment.

Electrification outlook for domestic two-wheeler market (fiscals 2025-2029)

The electric two-wheeler retails rose at a sharp growth pace of 101% CAGR in the last 6 years, albeit off the small base of fiscal 2019. Going ahead the growth momentum in the industry is expected to continue over the long-term horizon led by rising awareness, improving TCO for electric vehicles, bridging acquisition cost gap between EV and ICE counterparts, larger vehicle portfolio, expanding charging infrastructure, furthering financing support, increasing EV manufacturing capacity, and continued government support.

If the government continues with the demand incentive (FAME, EMPS or an equivalent alternate form) at least for the next 1 year (till fiscal 2026), CRISIL Intelligence expects the EV retails to rise at a healthy pace of 45-48% CAGR and reach 6.0-6.5 million levels in fiscal 2029. And the EV penetration levels to reach 23-25% by fiscal 2029.

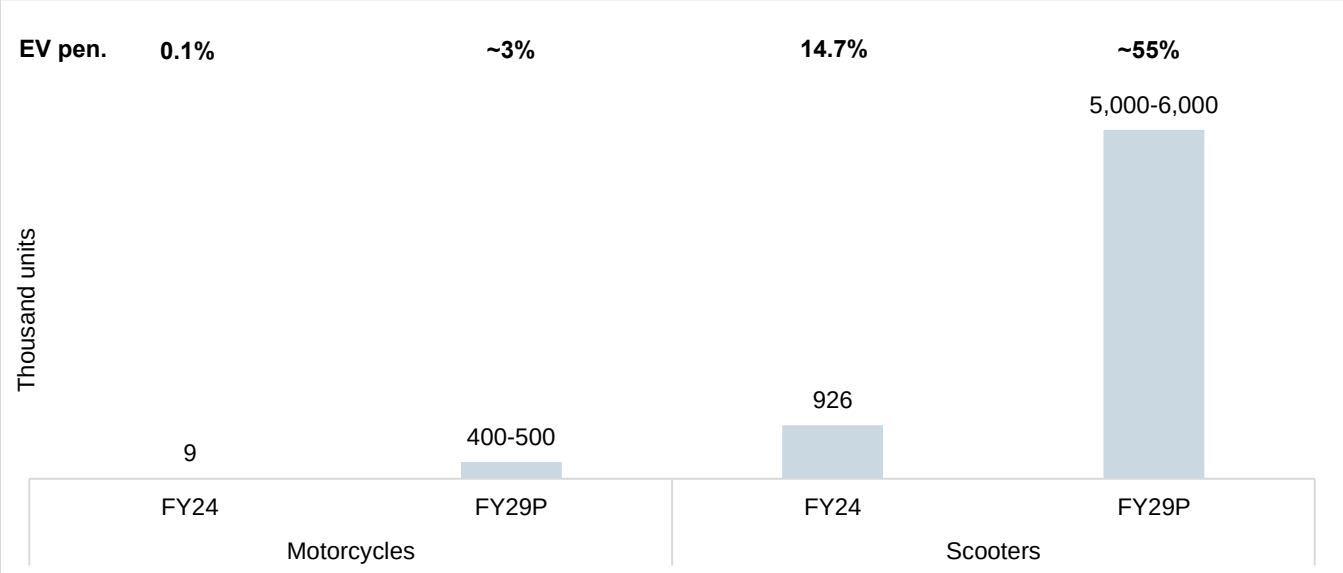
Electric two-wheelers and penetration outlook



Note: Only high-speed electric two-wheelers are considered for the analysis

Source: SIAM, SMEV, VAHAN, CRISIL Intelligence

Segment-wise EV outlook



Note: Only high-speed electric two-wheelers are considered for the analysis

Source: SIAM, SMEV, VAHAN, CRISIL Intelligence

Scooters are expected to lead the charge going ahead as well. EV penetration within scooters is currently the highest at 14.7% as of fiscal 2024. Amidst the fast-expanding e scooter portfolio, shifting of customer preference from ICE scooters to e scooters, OEM focus, state of the art advanced offerings, improvement in TCO as well as acquisition cost difference, a sharp rise in e scooter penetration is expected going forward. CRISIL Intelligence expects the EV penetration to reach ~55% for scooters by fiscal 2029.

Electrification within motorcycles segment has remained limited amidst limited offerings as well as typical longer distance usage of motorcycles compared to scooters. However, amidst the projected launch of e bikes/ motorcycles from OEMs including Revolt, OLA, Tork will back electrification within motorcycles as well. Over the longer horizon, EV penetration is expected to reach ~3% within motorcycles by fiscal 2029.

In the above projections, CRISIL Intelligence has considered the government demand incentive to continue till fiscal 2026 which will provide additional support to the EV adoption going forward.

Indian electric three-wheeler industry

Review of the electric three-wheeler industry (fiscals 2019 to 2024)

With the emphasis on reducing carbon footprint, EVs are gaining importance globally. India is a signatory to the Paris Agreement under the United Nations Framework Convention on Climate Change. The country is also part of the EV30@30 campaign, targeting a 30% sales share for EVs by 2030.

The government is extending its support via FAME and tax-rate cuts to boost EV adoption. Furthermore, growing awareness, concern for environmental issues and keener focus from automotive companies are driving electrification in India. The EV segment has received a real thrust over the past two years with model launches, increasing awareness, elevated fuel prices and improvement in infrastructure support.

The government announced Rs 100 billion for Phase II of FAME, which commenced on April 1, 2019. This phase mainly focuses on supporting electrification of public and shared transportation through demand incentives of 0.5 million for electric 3Ws. The policy aims to provide a subsidy of Rs 10,000 per kWh to 3Ws. It envisions the creation of infrastructure for EV charging. The subsidy for 2Ws is Rs 15,000 per kWh, although it was cut from June 2023, by lowering the cap on maximum subsidy from 40% of a vehicle's ex-showroom cost to 15%. EV adoption has been relatively fast in the 2W and 3W segments. A sharp rise in fuel costs over the past two years has provided an added incentive to the price-sensitive customers of 2Ws and 3Ws. Moreover, a bevy of vehicle launches from the industry backed the growth in adoption, especially in fiscal 2023.

Sales of e-3Ws in India

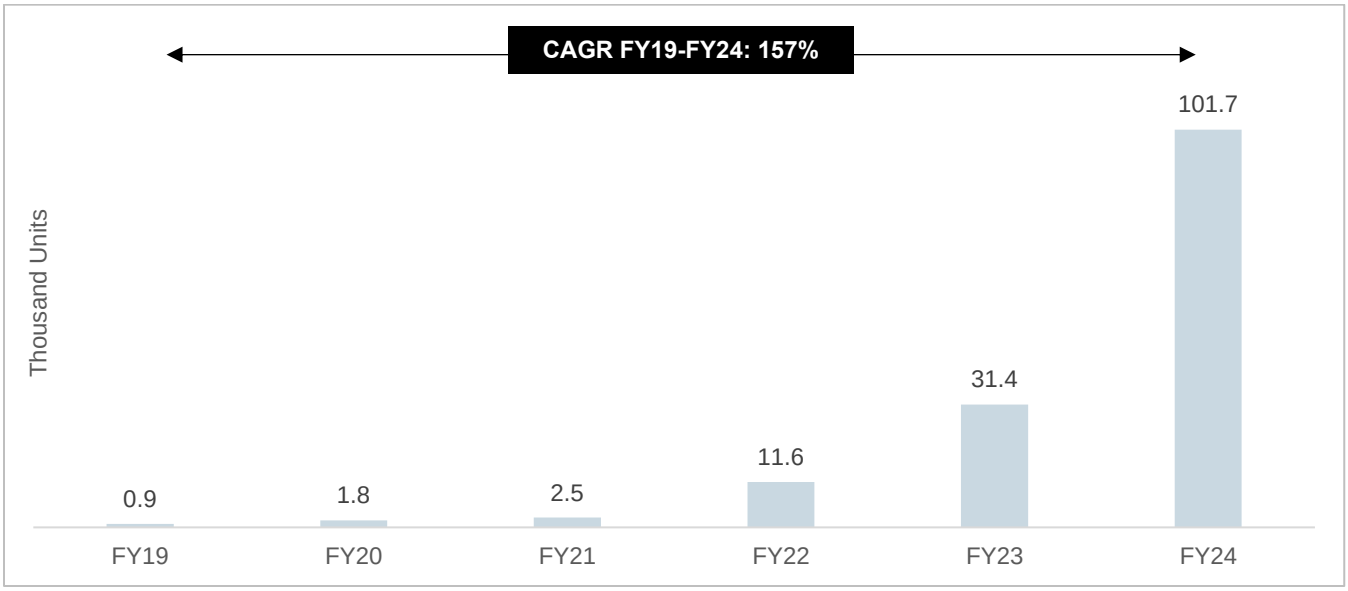
In the e-3W segment, mobility, especially in the case of e-rickshaws, is widely used for last-mile connectivity. E-autos and e-rikshaws differ primarily in the design specification of electric powertrain, performance (in terms of torque and maximum speed) and passenger capacity. E-rikshaws are a low-cost variant of e-3Ws, without an exact ICE counterpart.

The overall e-3W market logged a healthy CAGR of ~40% between fiscals 2019 and 2024. e-3Ws with high assured utilisation rates are more profitable for businesses, as they become economical to operate at higher utilisation. E-commerce giants prefer e-rikshaws for clean and economical last-mile connectivity.

In turn, the e-auto retails have grown at a significant pace of ~157% CAGR during Fiscal 2019- Fiscal 2024 period.

Conversely, the sales of ICE vehicles have contracted at approximately 4% during the same period, supporting the sharp growth in the e-auto penetration from an insignificant 0.1% in Fiscal 2019 to 16% by Fiscal 2024.

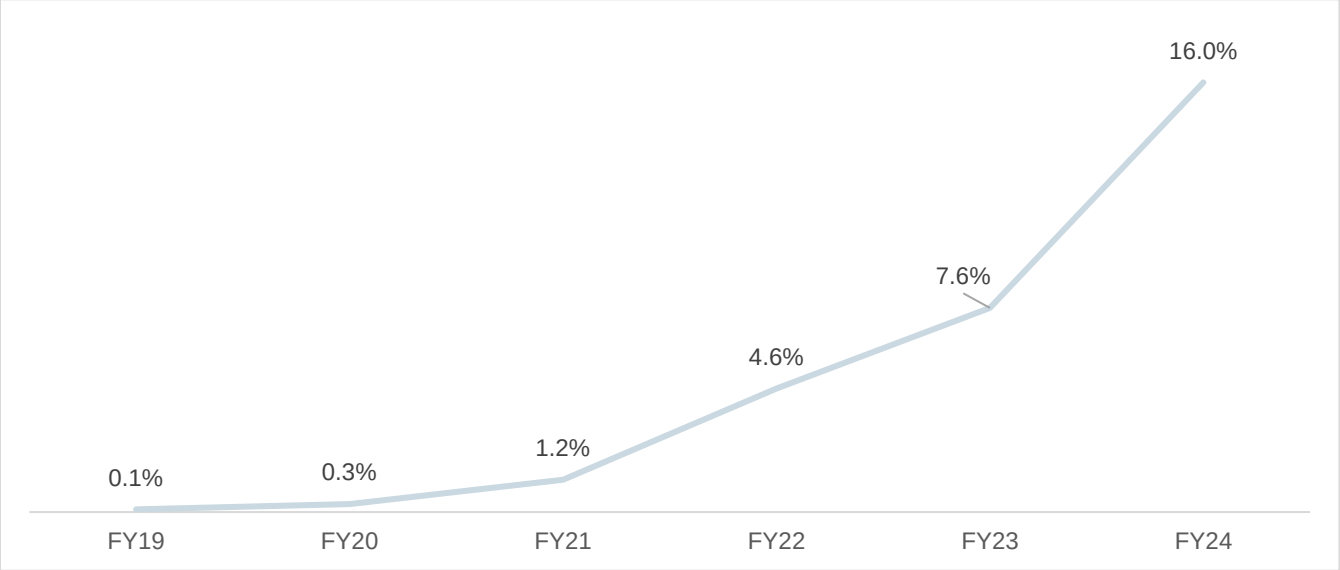
Figure: Electric 3W sales (E-auto)



Note: Electric 3Ws include e-autos and does not include e-rickshaws

Source: VAHAN, CRISIL Intelligence

Figure: EV penetration in 3Ws



Note: Electric 3Ws include e-autos and does not include e-rickshaws, Retail sales data from VAHAN has been considered for the analysis.

Source: VAHAN, CRISIL Intelligence

E-auto (i.e., the L5 category) rickshaws use lithium-ion batteries and have an average speed of more than 25 kmph. They are used for moving cargo as well as passengers. The leading players in this segment are Mahindra Electric and Piaggio. Under FAME-I, e-3Ws driven by lead-acid batteries were also eligible for subsidy. However, under FAME-II, only advanced batteries and registered vehicles are eligible. Higher initial cost of e-autos, lack of availability of a wide range of products in the market, and insufficient charging infrastructure have hindered their penetration (~5% in fiscal

2022). Despite these challenges, the shift towards e-autos has occurred due to their low operating costs, economic benefits and environmental friendliness.

Drivers of electrification

Replacement opportunity in 3Ws

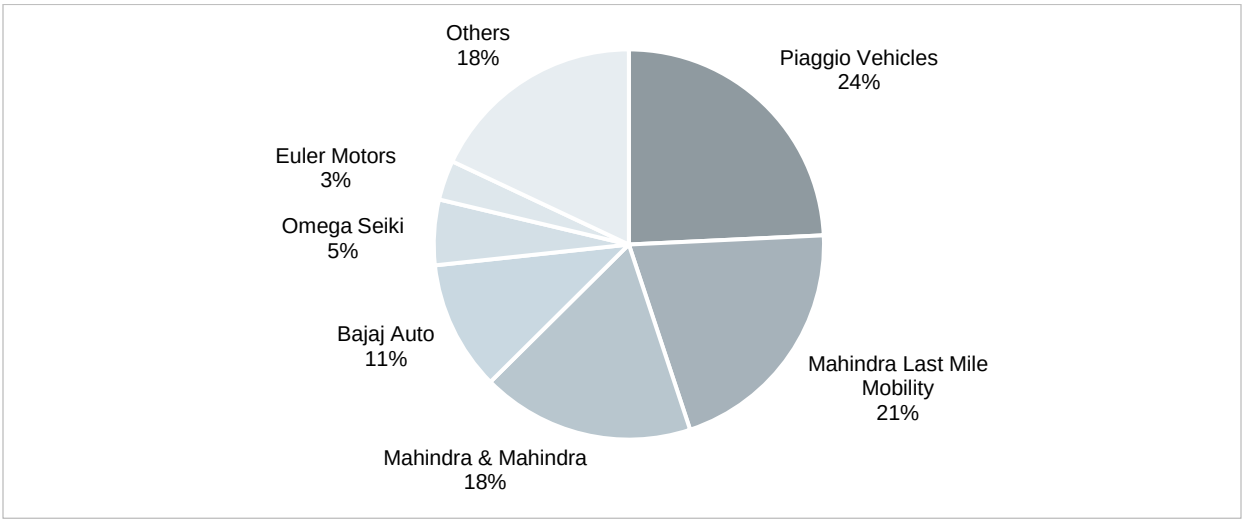
Following the pandemic, demand for 3Ws has improved as customers are upgrading and replacing their old fleets for higher uptime and cleaner vehicles. The replacement market for 3Ws has expanded. Pent-up demand from fiscal 2021 (when vehicular moment was restricted) had helped the segment last fiscal. It is expected to continue this fiscal, too. Further, demand in the replacement market is expected to grow owing to deeper penetration of electric 3Ws. Additionally, central and state subsidies have lowered the capital cost. Some of the states have either reduced or waived registration fees, road tax and permit requirement for electric 3Ws. Moreover, these vehicles have lower running costs. Overall, their cost of ownership is now much lower than conventional diesel or CNG 3Ws, rendering the shift to electric 3Ws attractive.

Other factors driving growth

- Favourable cost economics, strong charging infrastructure, and easy availability of finance should drive the growth of e-autos
- E-commerce delivery is an important segment in E-3W sales. An improving economy amid low-to-moderate inflation is expected to drive consumer spending, propelling retail-industry growth driving the sales of E-3W even further.
- A stronger infrastructure network (metro lines and road connectivity) and the need for zero-emission 3Ws for last-mile connectivity to also support electrification in the longer run.

Piaggio, Mahindra top players in electric 3W segment

Figure: Share of key players in electric 3W market (e-autos, FY24)



Note: Electric 3Ws do not include e-rickshaws

Source: VAHAN, CRISIL Intelligence

Mahindra Last Mile Mobility and Piaggio were the top two players in fiscal 2024, together accounting for over 45% of the electric 3W market. They saw strong growth in sales in the fiscal, as 3W operators looking to lower their operating costs amid high fuel prices switched to electric variants.

Unlike ICE vehicles, electric 3W passenger vehicles do not come under the ambit of the permit system, because of which customers prefer them. As more players launch products in this category, we expect it to drive 3W sales in general. Incentives under FAME-II and state EV policies are also expected to support.

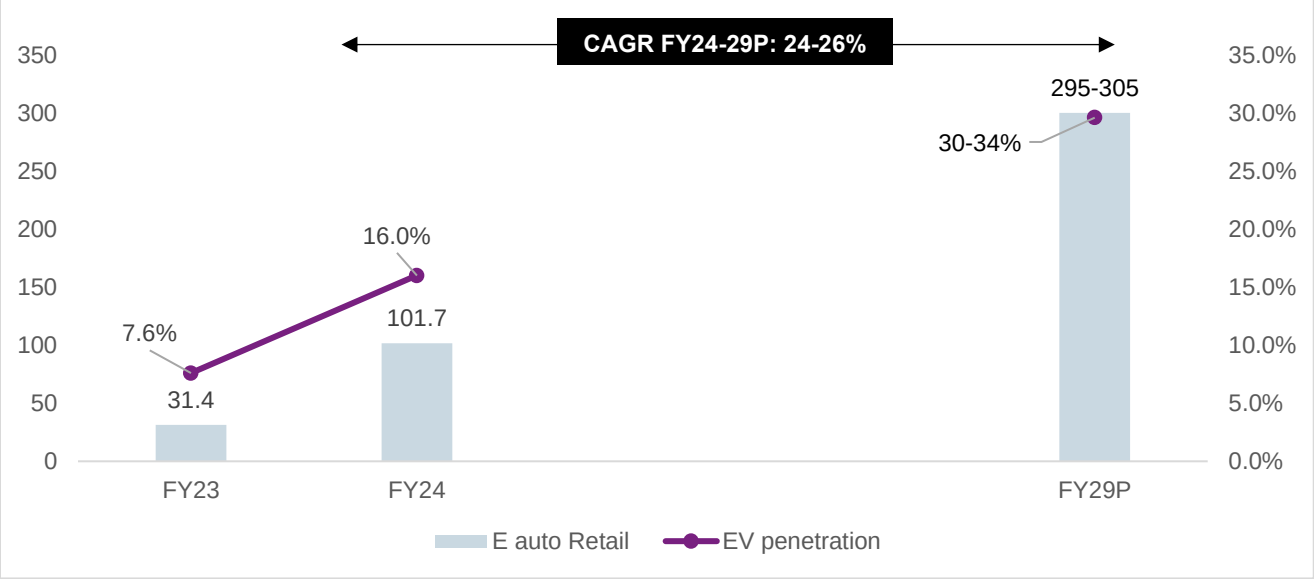
Outlook of the electric three-wheeler industry (fiscals 2024 to 2029)

CRISIL Intelligence expects EV penetration in the 3W segment to reach 30-34% by fiscal 2029. 3Ws will spearhead EV penetration in India because they are mostly used for short-distance trips and carry more load than e-rikshaws and e-bikes.

Moreover, all the conventional large OEMs, including Bajaj, Piaggio, Mahindra and TVS, have launched e-autos in the Indian market, which has improved their supply. This is expected to boost EV adoption in the long term.

Share of electric 3Ws to increase

Figure: Electric 3W sales outlook (in thousand units) and EV penetration outlook



Note: Electric 3Ws include e-autos and does not include e-rickshaws

Source: VAHAN, CRISIL Intelligence

The penetration of EVs in 3Ws was ~16% in fiscal 2024. However, the shift to electric 3Ws is gaining momentum owing to the high prices of diesel, petrol and CNG.

The electric 3W segment will continue to innovate and lead the industry as fixed and swappable battery solutions have revolutionised the sector. Also, leading OEMs are focused on electric 3Ws. Bajaj currently dominates the petrol segment, and its market share is expected to expand with aggressive initiatives in the EV space.

A favourable regulatory environment, along with central and state government subsidies, is lowering the capital cost of purchasing electric 3Ws. Also, reduction or waiver of registration fees, road taxes and permit requirement by some of the states continue to support EV adoption. Moreover, their TCO is 30-40% lower than conventional diesel or CNG 3Ws, making the conversion to electric autos an attractive proposition.

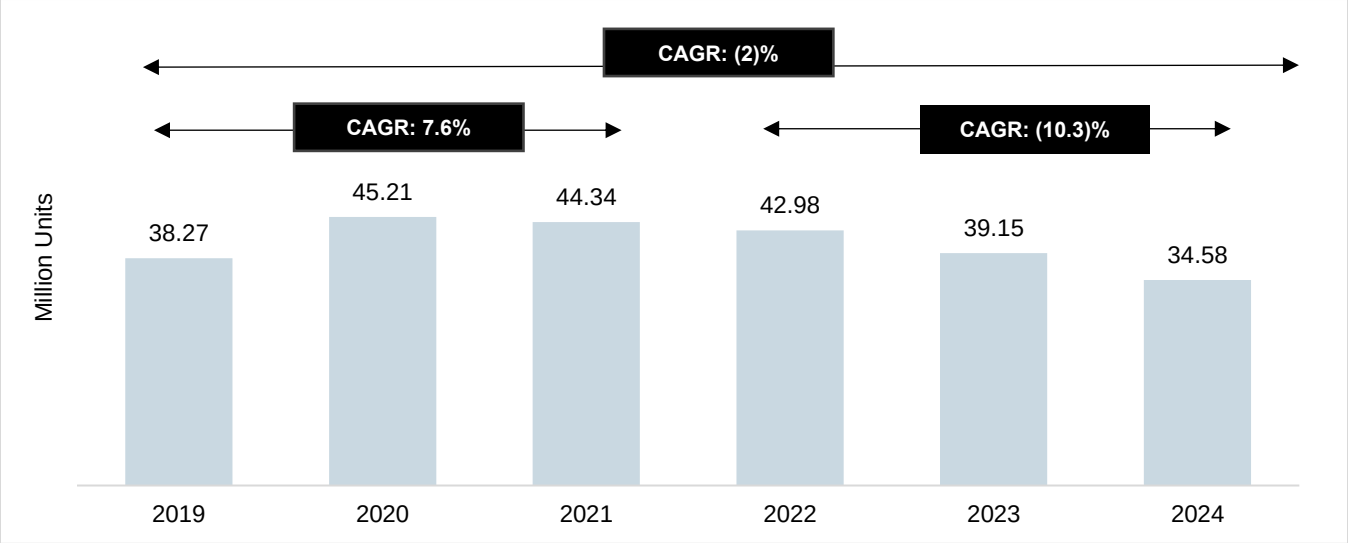
4. Global bicycle industry

Review of the global bicycle industry (2019 to 2024)

The bicycle industry is getting a powerful boost from electric bikes. E-bikes, with their humble beginnings in the late-19th century, have evolved from clunky prototypes to modern marvels. Early pedelecs with pedal-activated motors kickstarted wider appeal, and 21st-century advancements in battery technology and design have made e-bikes a serious contender for commuting, recreation and utility cycling. This e-bike surge is a boon for industry. It expands the customer base by attracting new riders and fuels innovation in areas such as battery tech, motor design and connected features, all while promoting sustainable transportation. Challenges such as regulations, cost and safety concerns remain, but the future looks promising. Lighter batteries, smarter features and diverse e-bike options are on the horizon. Collaboration between e-bike makers, policymakers and urban planners will be key to creating an e-bike-friendly world, propelling the bicycle industry towards a sustainable and accessible future.

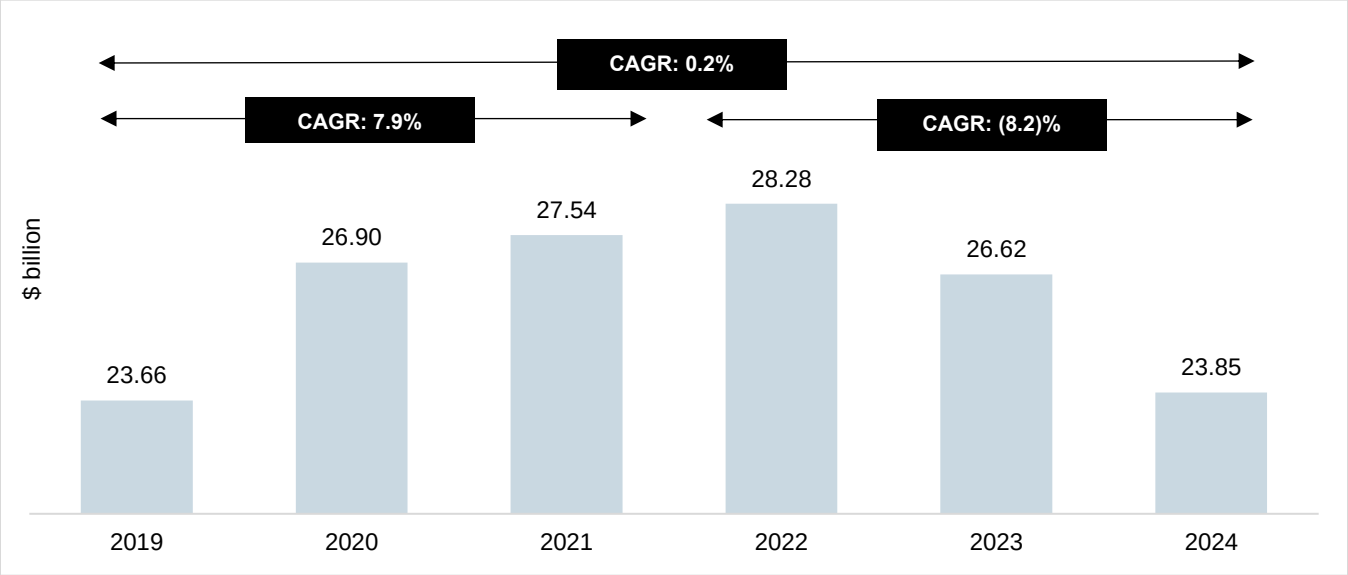
Historical production development (calendar years 2019-2024)

Overall bicycle market volumes



Note: Above figures include bicycle market volumes for conventional and electric combined for the US, Europe, Japan and ASEAN
ASEAN includes Singapore, Malaysia, Indonesia, Thailand, Vietnam, Philippines and Rest of ASEAN countries
Source: Mordor Intelligence, CRISIL INTELLIGENCE

Overall bicycle market value



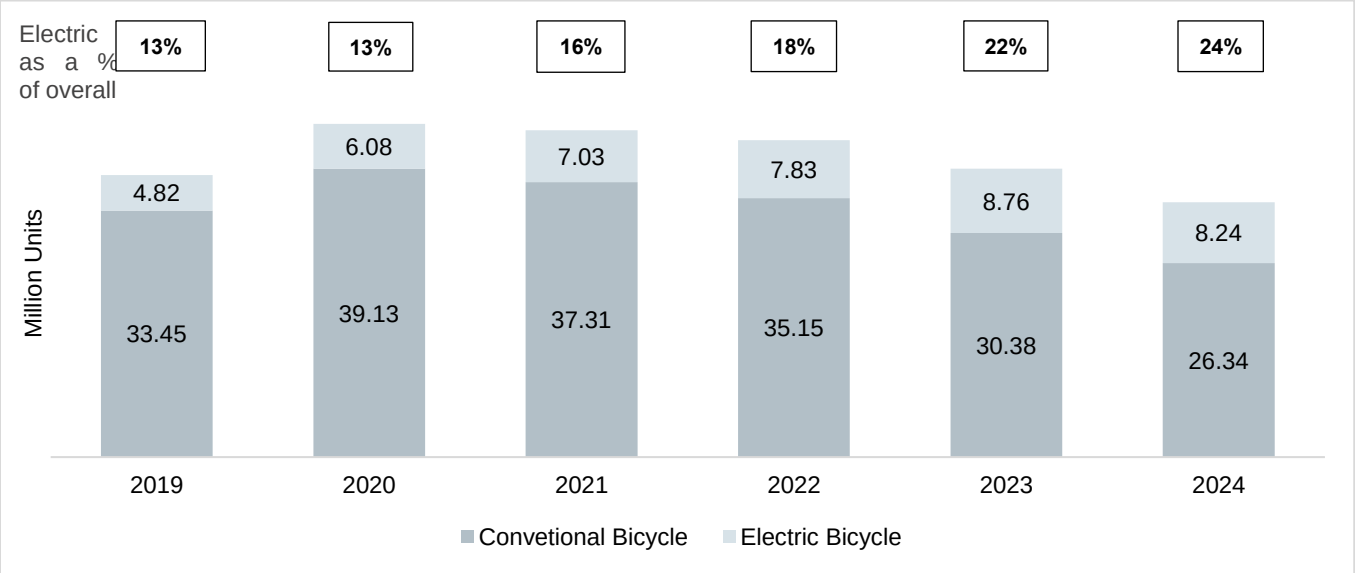
Note: Above figures include bicycle market value for conventional and electric combined for the US, Europe, Japan and ASEAN
ASEAN includes Singapore, Malaysia, Indonesia, Thailand, Vietnam, Philippines and Rest of ASEAN countries
Source: Mordor Intelligence, CRISIL INTELLIGENCE

There has been an increase in demand for electric bicycles in many countries over the past several years. Increased gasoline costs, traffic congestion during rush hours and the health advantages of exercise are driving the adoption of e-bikes in several countries, including the UK and the US. With a greater adoption rate in 2019 compared with other regions, Europe is the primary market for the sale of electric bikes.

The bicycle industry was favourably impacted by the rapid global expansion of Covid-19 cases. Both conventional and electric bicycles experienced significant growth in this period. While e-bikes garnered much attention, conventional bicycles remained the dominant force in terms of sales volume. Fuelled by a global focus on health and fitness, coupled with expanding cycling infrastructure in cities, conventional bicycles of all types saw a surge in popularity. Their affordability and accessibility compared with e-bikes further solidified their position. However, e-bikes emerged as a game-changer during the pandemic, offering assisted pedalling and attracting a broader demographic seeking less strenuous riding options.

Bicycle industry trends by product type

Segmentation by product type in volumes (calendar years 2019 to 2024)



Note: Above figures include bicycle market volumes for the US, Europe, Japan and ASEAN

Source: Mordor Intelligence, CRISIL INTELLIGENCE

During 2019-2021, the conventional bicycle market witnessed a CAGR of 5.6% in volume terms, backed by demand during Covid-19. However for the same, during 2022-2024, the market logged a negative CAGR of 13.4% as the trend for e-bikes had already picked up pace with geographies such as Europe and the US experiencing strong demand for e-bikes, which partially hit the share for conventional ones. For the overall period (2019-2024), the conventional bicycle market clocked a negative CAGR of 4.7%.

E-bikes, though lower in volumes than conventional bicycles, have already been experiencing a rising trend in demand as more people have started to opt for e-bikes over conventional ones. Also, governments in many countries have been constantly encouraging cycling with the announcement of policies/campaigns, driving more people towards cycling over other available transport options. E-bikes witnessed a CAGR of 11.32% during 2019-2024 in volume terms, with e-bikes almost accounting for ~24% of the entire global bicycle market by the end of 2024.

Nuances within the segment:

It is important to note that the conventional bicycle market is not monolithic. Sub-segments such as road bikes and mountain bikes may have experienced fluctuations based on their own specific trends and technological advancements. For example, the introduction of lighter materials or innovative gear-shifting mechanisms could drive growth within a specific segment of conventional bicycles.

E-bikes:

Electric bikes are appreciated for their efficiency, accessibility and minimal environmental impact. With advancements in battery technology, they offer extended ranges and excellent performance, making them the preferred choice for urban commuting. Governments globally, along with environmentally conscious consumers, are accelerating the shift to electric mobility, solidifying the dominance of e-bikes in the industry.

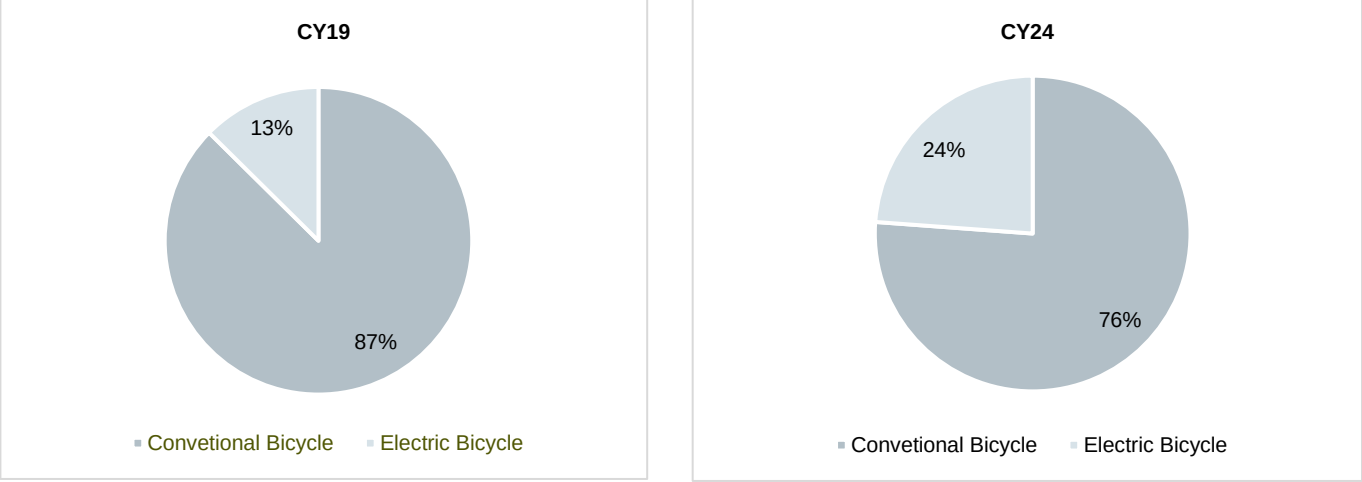
The e-bike market, in stark contrast, has witnessed a meteoric rise in recent years, fundamentally altering the bicycle industry. Following are some of the reasons for the same:

Broadened appeal: E-bikes have expanded the cycling demographic significantly. They cater to individuals who may find traditional bikes physically demanding, those seeking a more convenient way to navigate cities with hilly terrain, or even older adults who want to enjoy cycling without the exertion. This inclusivity has fuelled the e-bike revolution.

Technological advancements: Improvements in battery technology, motor efficiency and overall design have played a critical role. E-bikes are becoming lighter, offering longer ranges and boasting a more sleek aesthetic, making them more attractive to a wider range of riders.

Environmental alignment: The growing public focus on sustainability has positioned e-bikes as a compelling alternative to polluting vehicles. They offer a practical and eco-friendly mode of transportation, further propelling their popularity.

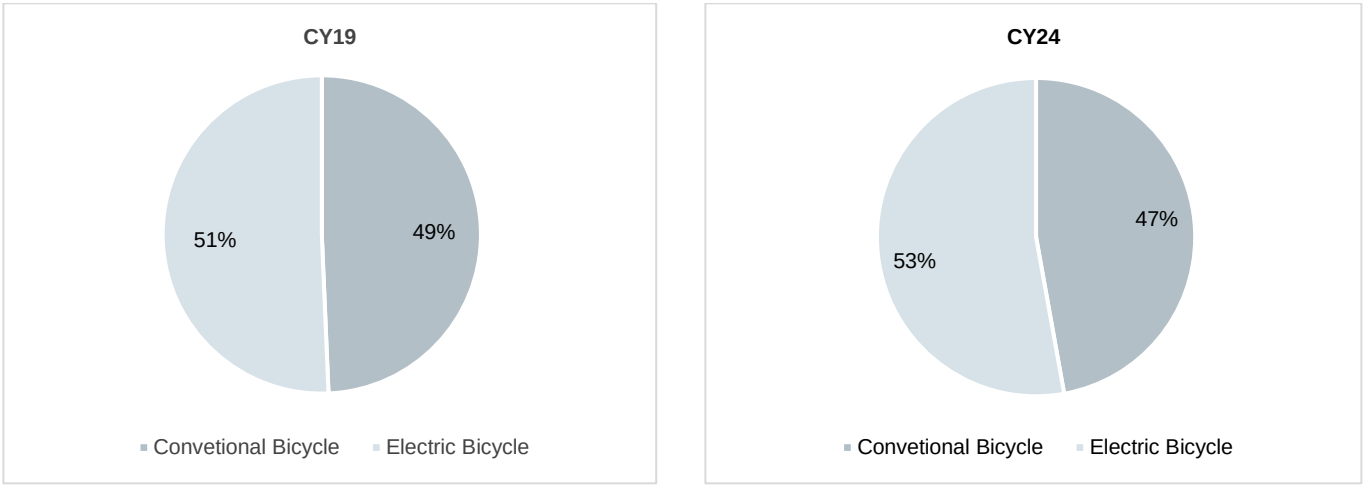
Trend in market share by bicycle type (in volume terms)



Note: Above figures are inclusive of geographies such as the US, Europe, Japan and ASEAN

Source: Mordor Intelligence, CRISIL INTELLIGENCE

Trend in market share by bicycle type (in value terms)



Note: Above figures are inclusive of geographies such as the US, Europe, Japan and ASEAN

Source: Mordor Intelligence, CRISIL INTELLIGENCE

As the global markets evolve and more people increasingly start to prefer electric bikes, the share of e-bikes is set to continue the increasing trend. In 2024, e-bikes recorded a market share of 24% — highest in the last six years. However, the e-bike boom has not been uniform across the globe. Following are some of the glimpses into the regional variations:

Europe: A leader in e-bike adoption, Europe boasts a well-developed market with high penetration rates and continued strong growth. Supportive government policies and existing cycling infrastructure have fuelled this trend.

China: A manufacturing powerhouse, China is a major player in both e-bike production and sales. The focus here is on affordability and practicality, with utility-focused e-bikes dominating the market.

North America: The North American market is experiencing rapid e-bike growth, with a focus on higher-end models and recreational use. Consumers here are increasingly drawn to the performance and technological advancements offered by premium e-bikes.

Japan: Japan's e-bike market is experiencing moderate growth, but with a unique twist. Innovation is a key focus, with manufacturers developing e-bikes tailored to an ageing population, such as compact models or those with features that enhance stability and comfort.

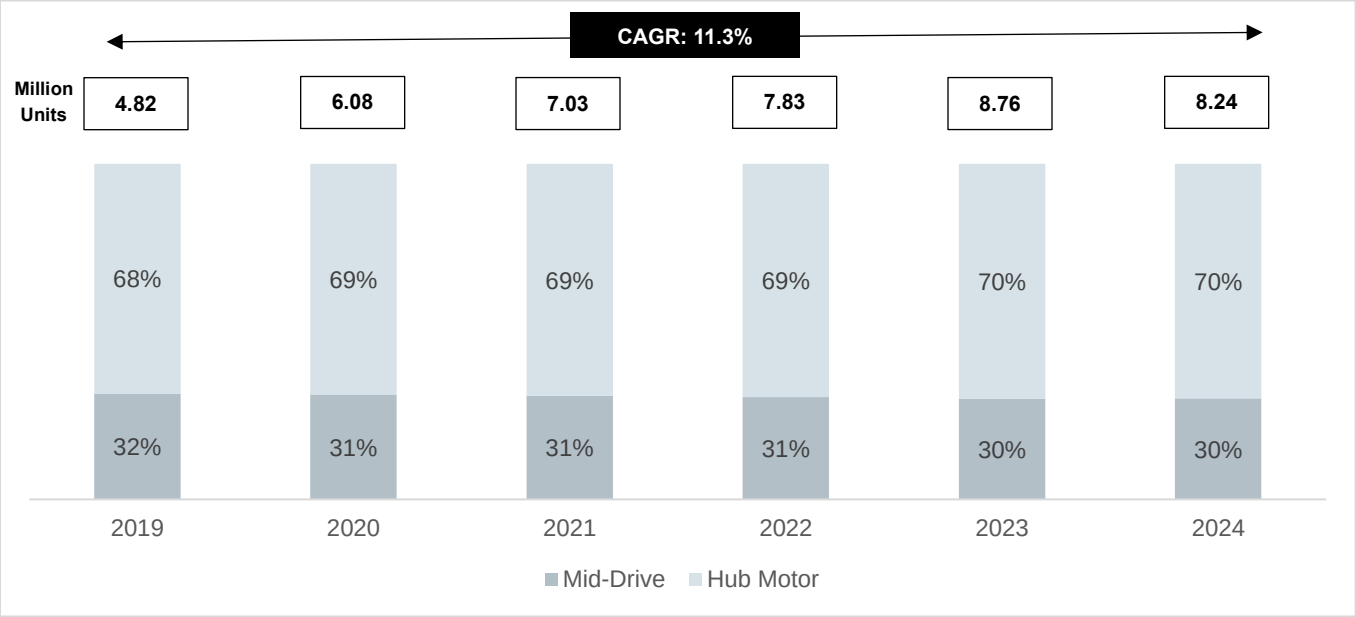
ASEAN: This emerging market presents a promising future for e-bikes. Rapid urbanisation, coupled with government initiatives promoting cycling, is creating fertile ground for e-bike adoption in Southeast Asia.

Going forward, the bicycle industry is likely to see a continuation of the e-bike surge. However, conventional bicycles are not expected to become obsolete. Instead, the market is poised for a future where both product types co-exist, catering to different needs and preferences. Factors such as affordability, technological advancements in both e-bikes and conventional bicycles, and continued infrastructure development for cyclists will play a crucial role in shaping the industry's trajectory. One thing is certain: The two-wheeled revolution is here to stay, with both conventional and e-bikes offering exciting possibilities for a more sustainable and healthy future.

Bicycle industry trends by motor type

The e-bike revolution has already gained significant momentum, with two distinct motor types vying for dominance: hub motors and mid-drive motors. Each offers a unique riding experience, catering to different rider profiles.

Overall share of e-bike market by motor type (in volume terms) (calendar years 2019 to 2024)

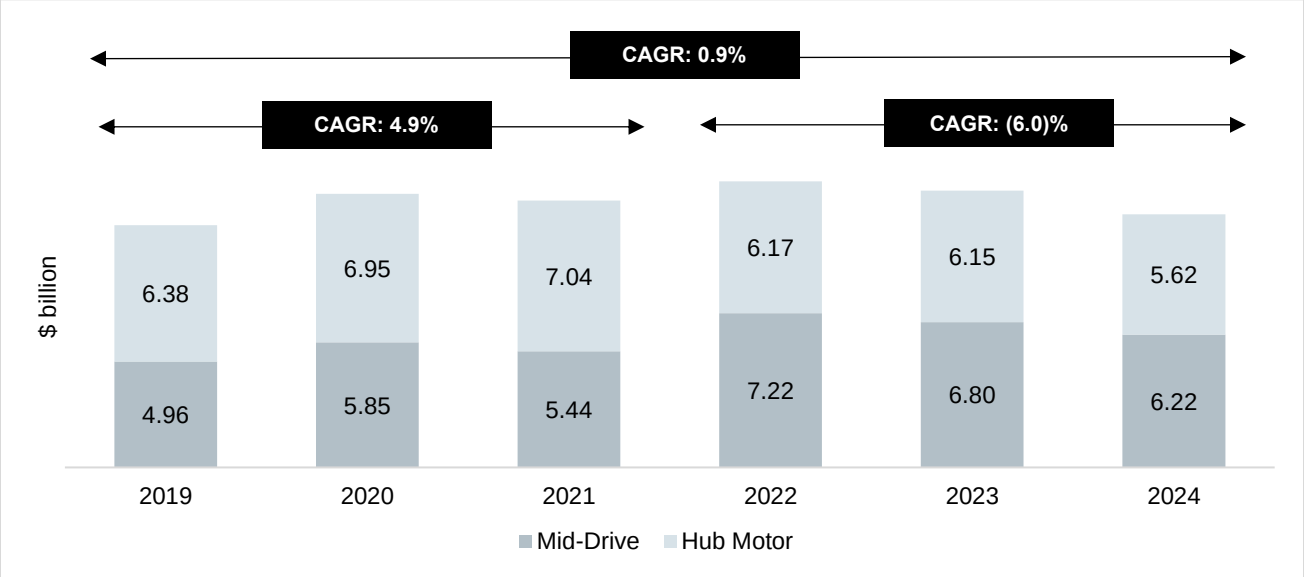


Note: The above figures are in million units and include e-bike market volumes for the US, Europe, Japan and ASEAN.

Source: Mordor Intelligence, CRISIL INTELLIGENCE

Hub motors, the silent workhorses of the e-bike world, are renowned for their affordability and user-friendly nature. Nestled discreetly within the front or rear wheel, they provide a comfortable and reliable boost of electric power, perfect for casual riders who enjoy leisurely cruises on flat terrain or budget-conscious commuters seeking a convenient way to navigate city streets. On the other hand, mid-drive motors occupy the heart of the e-bike, seamlessly integrating with the drivetrain to create a powerful and natural riding experience. They reign supreme in the realm of performance, offering superior torque that conquers hills with ease and mimics the familiar feel of traditional cycling.

Overall e-bike market value by motor type (calendar years 2019 to 2024)



Note: The above figures include bicycle market value for the US, Europe, Japan and ASEAN.

Source: Mordor Intelligence, CRISIL INTELLIGENCE

Hub motor

Hub motors, electric motors embedded directly within the wheel hub, have become a pivotal technology driving the growth of the e-bike industry. Their inherent advantages, including ease of use, reduced maintenance requirements and attractive price points, have fostered widespread adoption among a significant segment of the e-bike user base. However, inherent limitations necessitate ongoing innovation to ensure continued dominance in this burgeoning market.

Design

Wheel-centric powerhouse: Unlike its mid-drive counterpart, the hub motor becomes an integral part of the wheel itself. The motor housing replaces the standard hub, seamlessly integrating the electric motor with the wheel's rotation. Hub motors come in two main configurations: front-mounted and rear-mounted. Each offers distinct advantages:

- Front-mounted hub motor: This option generally offers a lighter overall weight distribution for the e-bike and can be slightly more affordable. However, it might provide a less natural riding experience due to the altered weight distribution and the potential for a slight dragging sensation when not using the motor assist.
- Rear-mounted hub motor: This configuration offers a more intuitive riding experience as the power delivery closely mimics that of traditional pedalling. Additionally, rear-mounted hub motors can benefit from the existing drivetrain components, potentially offering greater efficiency and torque.

One of the most significant advantages of hub motors is their affordability. The simpler design and fewer moving parts translate to lower production costs compared to mid-drive motors. Hub motors are renowned for their user-friendly nature. The simpler design typically requires less maintenance compared to mid-drive motors.

Major players in the hub motor space

The global hub motor market for e-bikes is dominated by several key players, with China leading the charge through manufacturers like Bafang, MXUS, QS Motor, and Tongsheng. Certain suppliers from the Asia-Pacific region account for majority of global volumes. Europe also has notable contributors such as Bosch, Mahle, and Heinzmann, while Japan is represented by established technology giants like Shimano and Panasonic. In North America, Grin Technologies has carved a niche in the aftermarket and custom solutions space. These companies collectively support a wide range of applications, from lightweight city e-bikes to high-torque cargo and performance-oriented models.

Bafang, a dominant player offering versatile and widely adopted systems across all bike categories, and **MXUS**, known for cost-effective, high-torque rear hub motors popular in the aftermarket. **QS Motor** specializes in powerful hub motors for cargo and utility applications, while **Tongsheng** caters to budget-conscious users with basic hub motor solutions.

In Europe, **Bosch** and **Mahle** focus on integrated, high-quality systems - Bosch primarily on mid-drives with some hub motor applications, and Mahle on sleek, lightweight rear hub motors for urban and road bikes. **Heinzmann** provides industrial-grade hub motors for utility and fleet use.

From Japan, **Shimano** and **Panasonic** offer hub motors in select commuter and entry-level e-bikes. **Grin Technologies** in North America stands out in the DIY and custom conversion space with modular hub motor kits.

There are certain emerging players with good market presence whereas only limited companies provide comprehensive solutions to the e-bike market. On the other hand, certain entry-level players offer cost-effective customized solutions as well. Nevertheless, there are only a few players that provide fully integrated systems.

Mid-drive motor

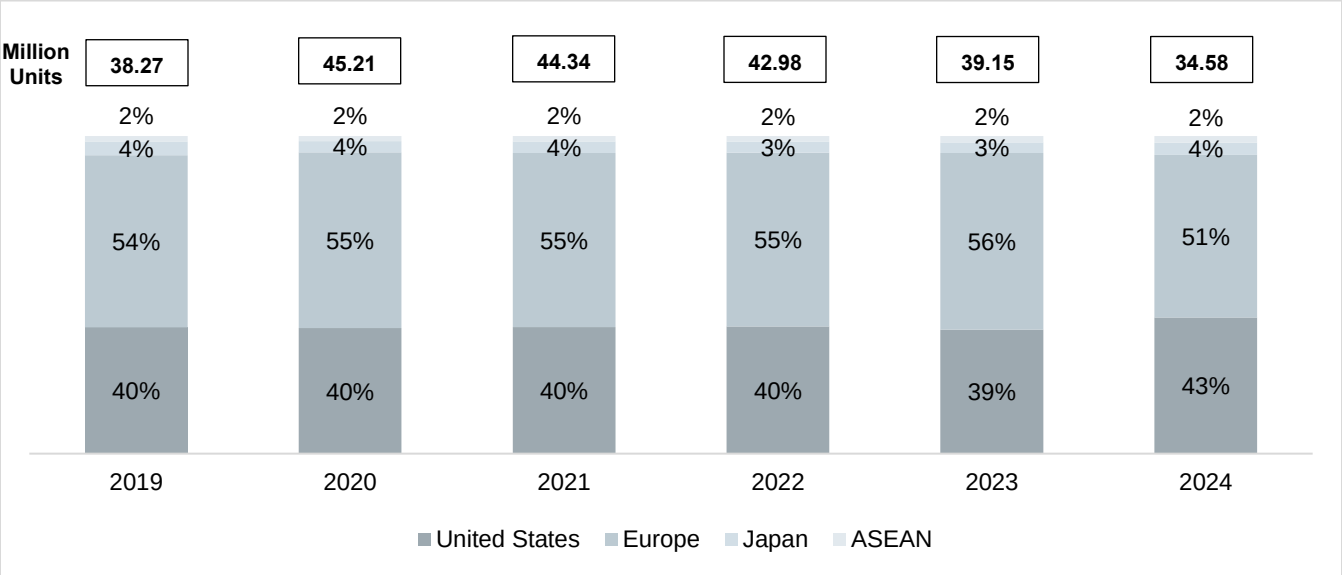
The mid-drive motor sits at the centre of an e-bike's performance, seamlessly integrated with the drivetrain and offering a riding experience that closely mimics traditional cycling. Unlike the hub motor that resides within the wheel, the mid-drive motor becomes the heart of the e-bike's power delivery system. Unlike hub motors, mid-drive motors are positioned near the pedals, typically mounted directly on the frame of the e-bike. They connect with the bicycle's crank set and cassette, essentially working in conjunction with the existing gears. This creates a more natural riding experience as the motor's power augments rider’s pedalling effort.

Major players in the mid-drive motor space

The mid-drive motor market is dominated by a few key players: Bosch, Shimano and Yamaha. Each offers unique strengths — Bosch prioritises power and user experience, Shimano focuses on performance and efficiency with smooth integration into its drivetrains, and Yamaha emphasises user-friendliness and quiet operation, and specialised motors for a natural riding feel. These companies develop and manufacture motors that integrate with the e-bike's drivetrain, providing torque for tackling hills and a natural cycling experience, while potentially offering greater efficiency than hub motors.

Bicycle industry trends in different geographies

Bicycle market volume share, by geography (calendar years 2019 to 2024)



Notes: Above figures include bicycle market volumes for the US, Europe, Japan and ASEAN

Source: Mordor Intelligence, CRISIL INTELLIGENCE

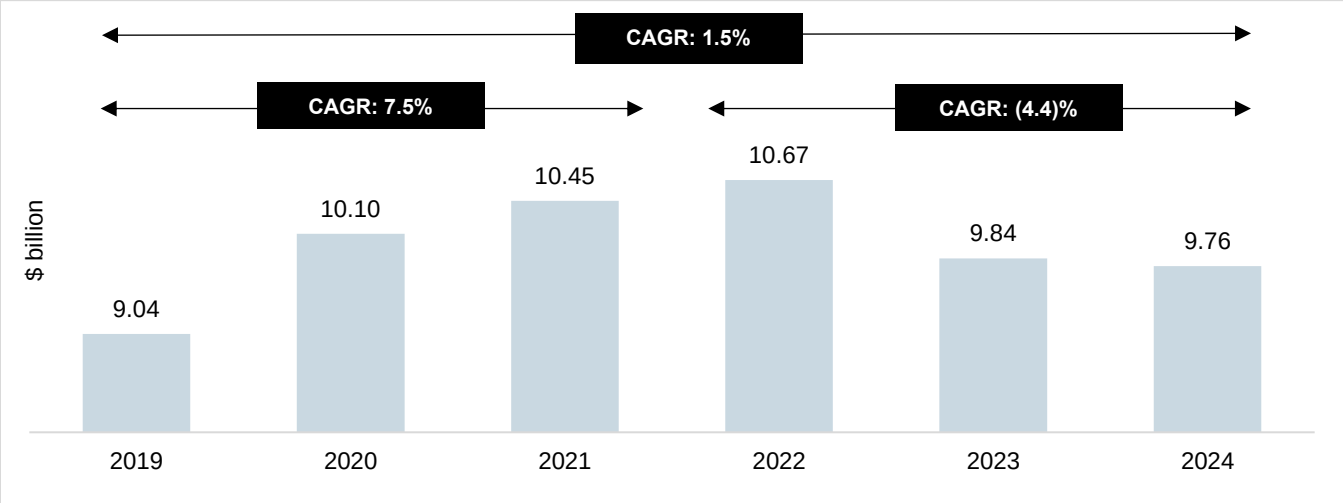
The global bicycle industry has witnessed a remarkable boom in recent years, fuelled by a confluence of factors. A growing focus on health and sustainability has spurred a long-term trend towards cycling, with people increasingly viewing it as a practical and eco-friendly transportation option. In urban areas worldwide, traffic congestion has reached a tipping point, making cycling a more attractive alternative for short-distance commutes. The affordability and popularity of e-bikes have been a game-changer, attracting new demographics to cycling who may have previously found traditional bikes physically demanding.

This surge in cycling enthusiasm is not uniform across the globe, but the underlying drivers share common threads. In China, for example, government initiatives promoting cycling infrastructure and e-bikes have complemented the existing focus on urban mobility due to traffic congestion. The US experienced a temporary boom during the pandemic as concerns about public transportation and a desire for outdoor activities drove bike sales. While sales have not remained at those highs, they are projected to stay elevated compared with pre-pandemic levels, suggesting a potential long-term shift in consumer behaviour. Europe, with its well-developed cycling infrastructure and strong environmental consciousness, has seen steady growth, particularly in the e-bike segment. Japan, with its established cycling culture, is experiencing moderate growth fuelled by innovation and the development of e-bikes tailored to an ageing population. Finally, the ASEAN region presents a promising emerging market with rapid urbanisation, a growing middle class and government support for cycling infrastructure.

The global bicycle industry is thriving, thanks to a perfect storm of health and sustainability concerns, urban challenges, and the rise of e-bikes. While regional nuances exist, the overall trend points towards a future where cycling plays a more prominent role in transportation and recreation.

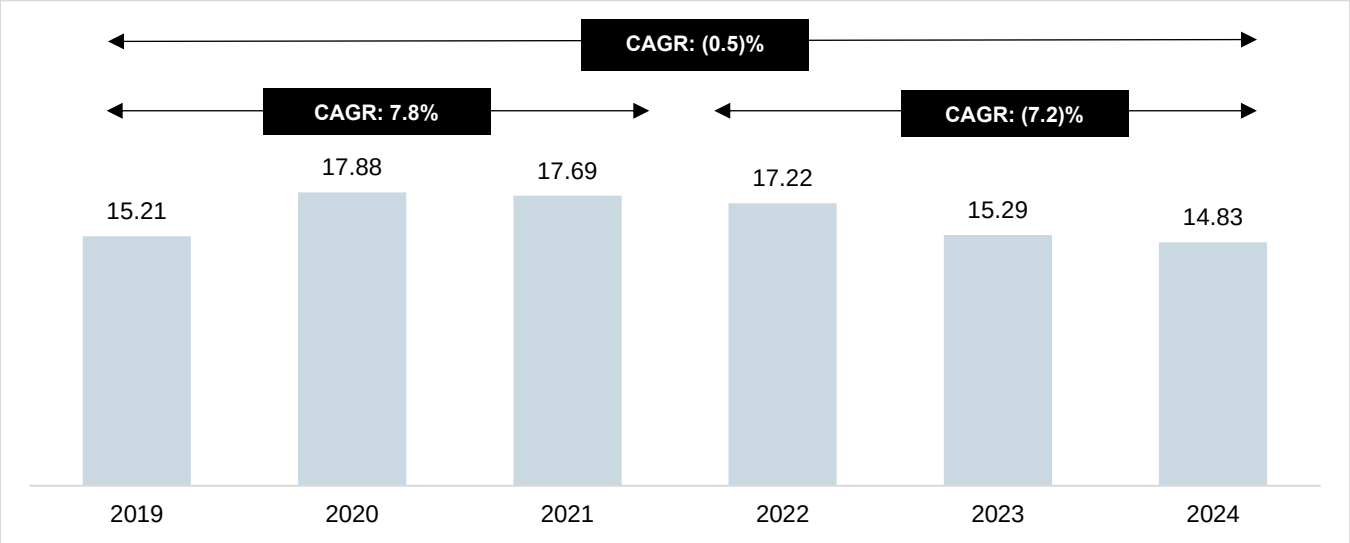
United States

US - market value (calendar years 2019 to 2024)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

US - market volume in million units (calendar years 2019 to 2024)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

The US bicycle market has experienced a remarkable surge in recent years, driven by a confluence of factors.

Prior to the Covid-19 pandemic, the US bicycle market exhibited a relatively stable growth pattern. Sales figures hovered around the 15 million unit mark, with a mix of traditional bicycles and a nascent electric bicycle (e-bike) market. The year 2020 marked a turning point. As the pandemic unfolded, concerns about public transportation and a desire for outdoor activities led to a surge in bicycle sales. This resulted in a nearly 18% on-year increase, with sales figures reaching an estimated 17.69 million units in 2021.

In revenue terms, the US bicycle market witnessed a CAGR of 1.5% between 2019 and 2024, whereas in volume terms, it logged a CAGR of (0.5)%. 2023 and 2024 saw some challenges in the industry with respect to high inventory

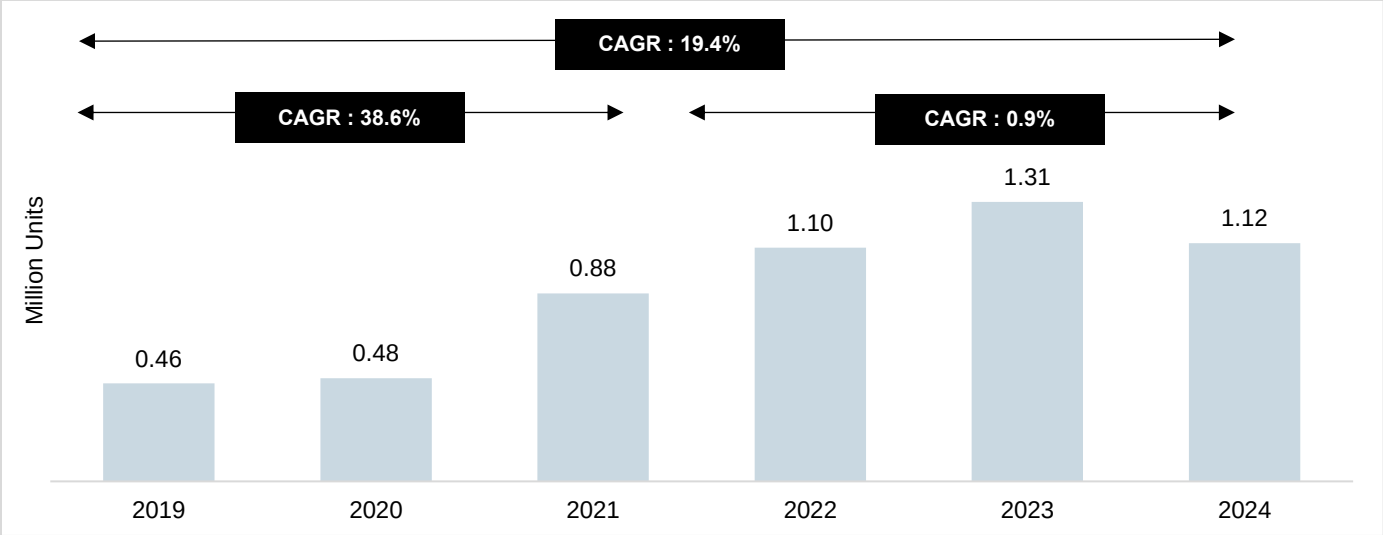
levels as players had maintained excess stock in anticipation of continued trend of increased demand seen during the Covid-19 period (2020-2022). However, the demand could not maintain that trend, eventually leading the industry into a downturn in 2023 and 2024.

Major reasons for the boom:

Several factors contributed to the US bicycle market growth:

- Covid-19 pandemic: Public health concerns and social distancing measures spurred a rise in cycling for recreation and essential transportation
- Increased focus on health and wellness: The pandemic heightened awareness of personal health, and cycling's well-documented health benefits attracted new riders
- Shifting transportation landscape: Rising fuel costs and growing congestion in urban areas made cycling a more attractive alternative for short-distance trips
- E-bike growth: Increasing trend in the disposable income of people reflected in the increased affordability and popularity of e-bikes to a wider demographic, including those who may have found traditional bikes physically demanding. The share of e-bikes in the US bicycle industry witnessed a significant surge between 2019 and 2024. In 2019, only 3% of the entire bicycle industry consisted of e-bikes, whereas the share reached ~8% in 2024, as demand for e-bikes took an upward trajectory

E-bike industry volumes in US (calendar years 2019 to 2024)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

The e-bike market witnessed a CAGR of 38.6% between 2019 and 2021 and 0.9% between 2022 and 2024. Overall, the CAGR between 2019 and 2024 was 19.4%, with volumes reaching 1.12 million units in 2024, which clearly indicates significant growth in the e-bike segment in the US over the years.

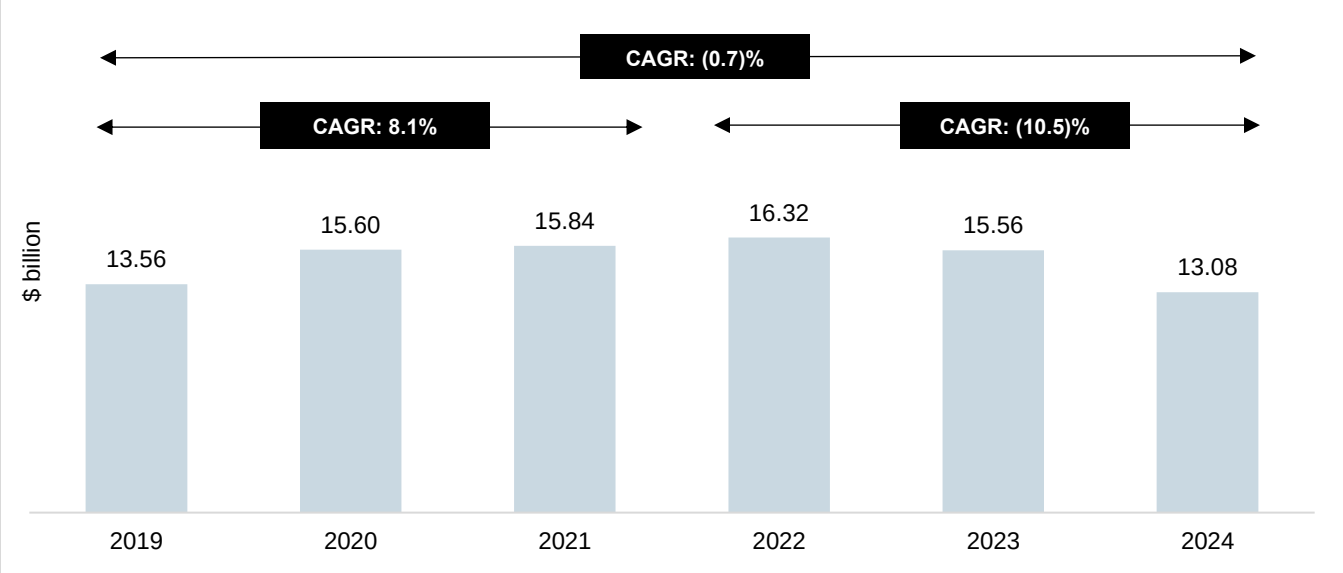
On the other hand, retailers are also focusing on youth living in big cities, as they prefer to commute by bicycle instead of a car to avoid the inconveniences and responsibilities that accompany car ownership, such as insurance, parking, gas, licensing, and overall maintenance costs. According to the Sports & Fitness Industry Association (SFIA), in 2024,

the participation rate for active Americans reached 80 percent, which means 247.1 million Americans participated in at least one activity in 2024 — an increase of 25.4 million more active Americans per year since 2019.

A potential long-term shift in consumer behaviour, with cycling gaining increased traction, US bicycle industry is well poised for a continued growth momentum provided there is increased government support for the bicycle industry.

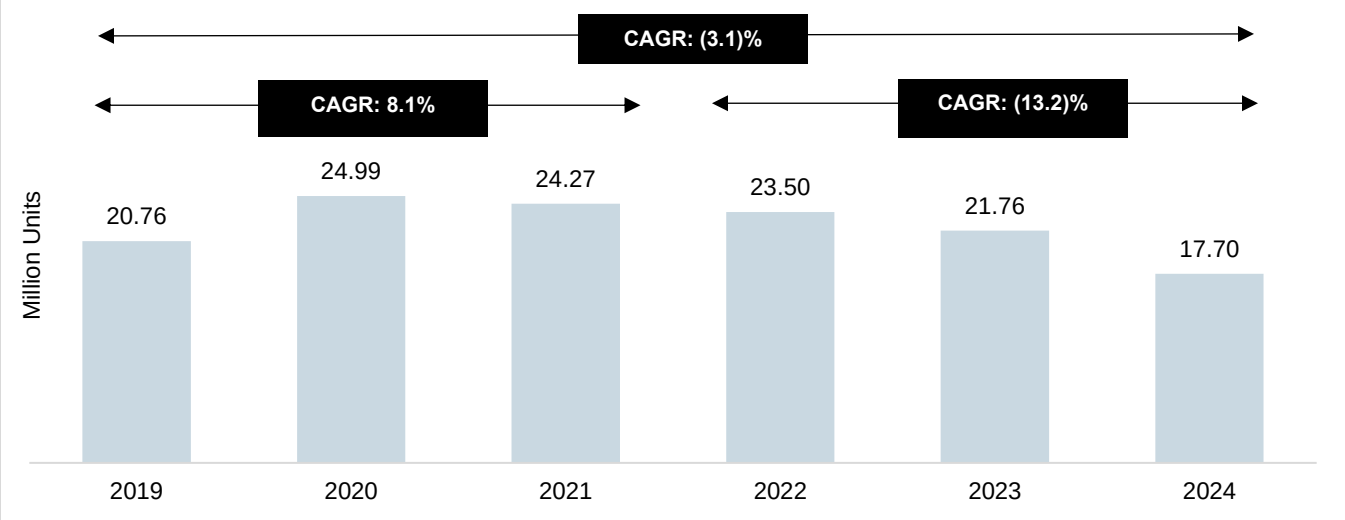
Europe

Europe – market value (calendar years 2019 to 2024)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

Europe – market volume in million units (calendar years 2019 to 2023)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

The European market has been on the go for the past six years and has not experienced any major market fluctuations that could have impacted the bicycle industry drastically. However, in 2024, the industry witnessed decline in volumes

due to economic pressures reducing consumer spending, excess inventory from overproduction during the pandemic, and a delayed cycling season leading to market saturation. In revenue terms, the European bicycle market witnessed a CAGR of (0.7)% between 2019 and 2024, whereas in volume terms, it logged a CAGR of (3.1)% during the same period.

Key drivers of the European bicycle boom:

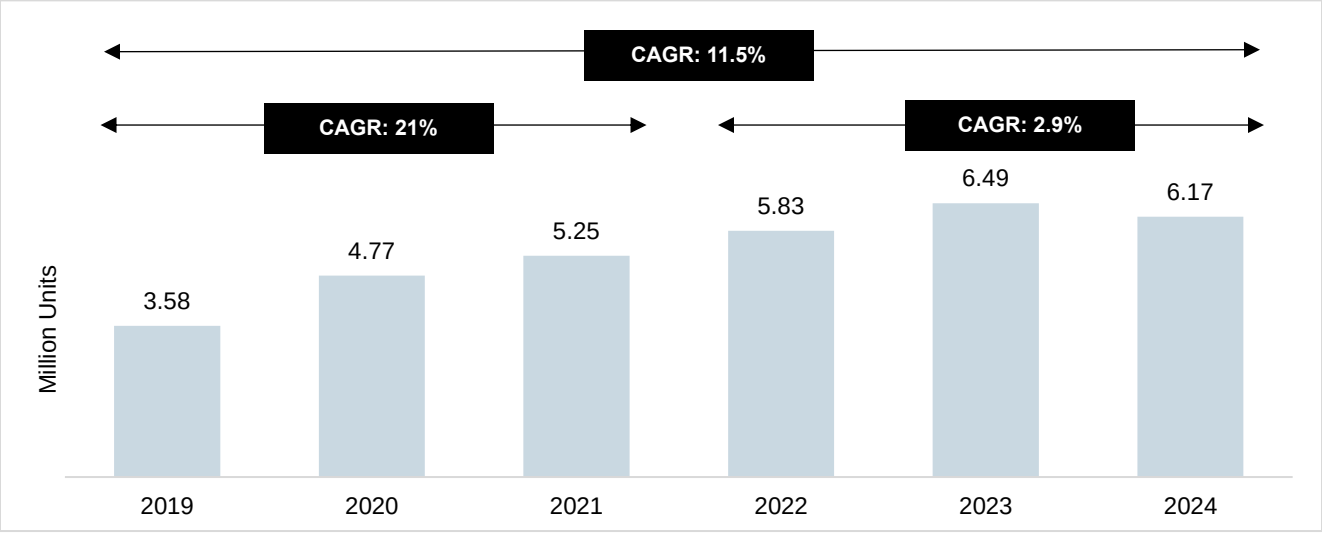
- Pre-existing cycling culture: Europe boasts a long-standing tradition of cycling, with well-developed infrastructure in many cities. This existing foundation facilitated further growth
- Environmental concerns: Growing environmental consciousness has positioned cycling as a sustainable transportation choice, aligning perfectly with European values
- Rise of e-bikes: Rising disposable incomes further increased the spending capacities of people, which has helped e-bikes on affordability fronts. They offer an assisted ride, attracting new demographics and making cycling more accessible for various fitness levels
- Focus on urban mobility: Traffic congestion in European cities has reached a critical point, making cycling a viable alternative for short-distance trips
- Road infrastructure: Urban planning in Europe is conducive to bicycle transport, as governments there encourage cycling to a greater extent and therefore plan road infrastructure that is conducive to cycling.

The e-bike revolution and its impact:

The rise of e-bikes has been significant both in volume and value terms. The charts below clearly indicate the rise in preference for e-bikes in European markets, contributing to the rising revenue from e-bikes, which even surpassed the revenue from conventional bikes in 2023.

Europe's e-bike surge stems from environmental concerns, health benefits, and economic factors. E-bikes offer a clean alternative to cars, promote exercise, and boast cost-efficiency with government incentives. This eco-friendly and practical mode of transport is reshaping European mobility.

E-bike industry volumes in Europe (calendar years 2019 to 2024)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

E-bike share increased from approximately 17% in 2019 to 35% in 2024, indicating an increased trend in usage of e-bikes in Europe. The industry witnessed a CAGR of 21% between 2019 and 2021 and 2.9% between 2022 and 2024. Overall, between 2019 and 2024, the European e-bike industry logged a CAGR of 11.5%, with volumes reaching up to 6.17 million units in 2024.

E-bikes have been a game-changer for the European market. These bicycles have broadened the appeal of cycling by:

- Catering to diverse needs: E-bikes cater to a wider range of riders, including those who may find traditional bikes physically demanding or those seeking a more convenient way to navigate cities
- Extending range and comfort: E-bikes allow riders to travel longer distances with less effort, making cycling a more practical commuting option
- Boosting recreational cycling: E-bikes have opened the possibility of recreational cycling for a wider audience, contributing to an overall rise in cycling participation

While the entire continent is experiencing a surge in e-bike popularity, the growth rate and market penetration vary significantly by country. Following is the country-wise break-up mentioning key factors contributing to the growth of the e-bike market in Europe:

Germany: The undisputed leader of European e-bikes, Germany boasts the highest sales figures and ownership rates. This can be attributed to a strong cycling culture, government subsidies and a well-developed network of cycling infrastructure.

Netherlands: Another forerunner in cycling infrastructure and e-bike adoption, the Netherlands is known for its cycling-friendly cities and a population that readily embraces e-bikes for commuting and leisure.

France: With a growing focus on sustainability and urban mobility, France is experiencing a rapid rise in e-bike sales. Government incentives and increasing awareness of the environmental benefits of e-bikes are fuelling this trend.

Poland: This region represents a significant growth market for e-bikes. Increasing disposable income and growing awareness of e-bikes are driving sales, with Poland poised to become a major European e-bike player in the coming years.

Czech Republic: Similar to Poland, the Czech Republic is witnessing a surge in e-bike popularity. Affordable e-bike options and a growing network of cycling paths are contributing to this trend.

Hungary: While lagging behind Western Europe, Hungary is experiencing a steady rise in e-bike sales. Government subsidies and increasing urbanisation are expected to accelerate e-bike adoption in the coming years.

Italy: E-bikes are gaining traction in Italy, particularly for leisure cycling and tourism. The country's beautiful landscapes and focus on outdoor activities are creating a strong market for e-bikes.

Spain: Similar to Italy, Spain is seeing a rise in e-bikes for leisure and tourism purposes. The country's warm climate and growing bike-sharing programmes contribute to this trend.

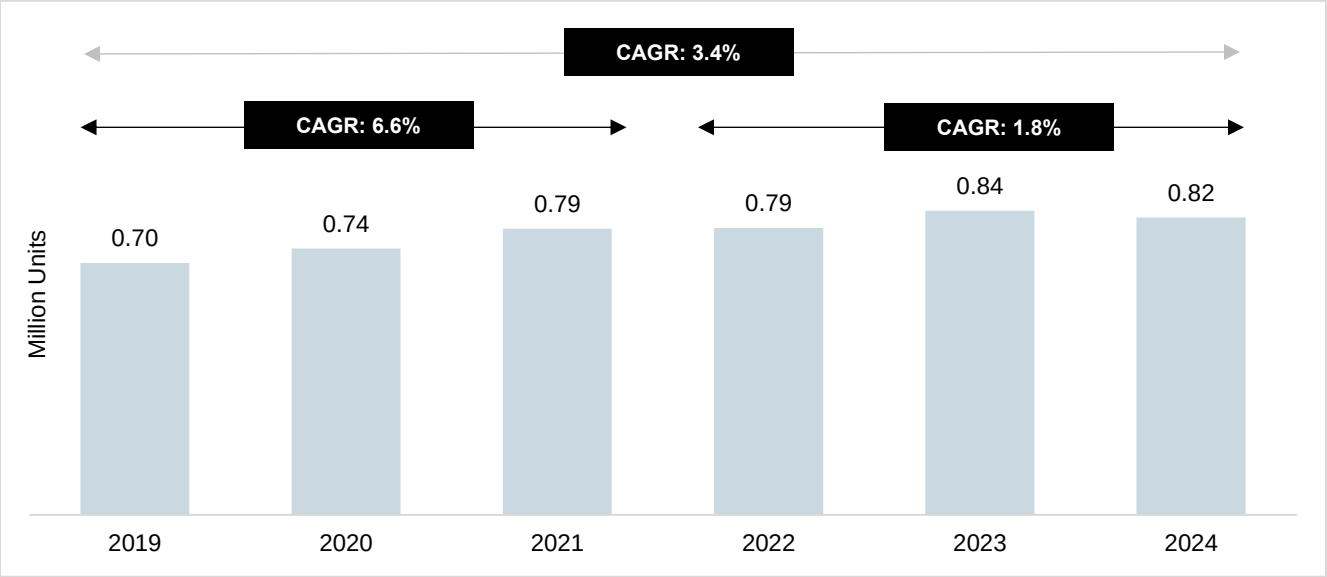
Greece: E-bike adoption in Greece is still in its early stages, but the potential for growth is significant. Government initiatives promoting cycling and the increasing popularity of e-bikes for tourism are promising signs.

The European bicycle market is expected to see further growth in the coming years. However, continued progress hinges on some key factors, such as investment in infrastructure, increased government support, and technological advancements with respect to batteries and motors, which will help enhance riding experience and attract more riders.

Japan

As Japan's population ages, the market has begun to adapt to meet the evolving needs of its riders. E-bikes have emerged as a compelling option for older adults who may find traditional bicycles physically demanding. While the e-bike revolution has not quite reached the same heights as in Europe, it presents a significant growth opportunity in Japan. The market is strategically shifting to cater to this segment, offering a comfortable and convenient mode of transportation that does not compromise on the established cycling culture. The share of e-bikes in Japan has seen a significant jump from approximately 43% in 2019 to 62% in 2024.

E-bike industry volumes in Japan (calendar years 2019 to 2024)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

Japan’s e-bike industry witnessed a CAGR of 6.6% between 2019 and 2021 and 1.8% between 2022 and 2024, and an overall CAGR of 3.4% between 2019 and 2024.

The future of Japan's bicycle market hinges on two key trends:

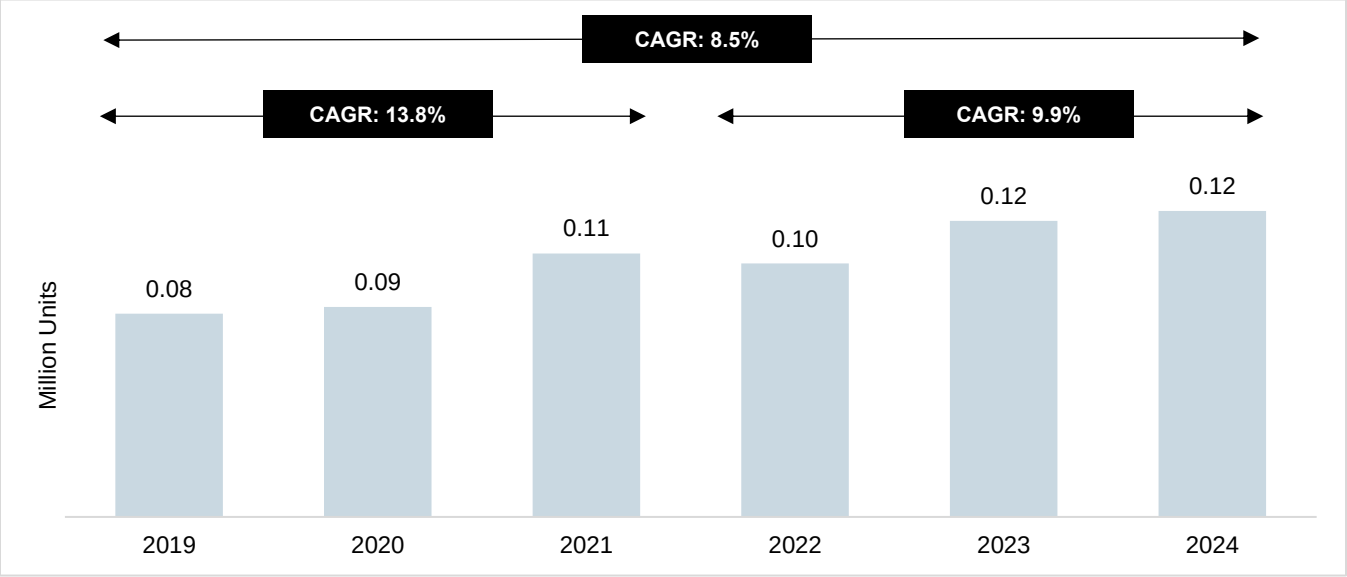
- E-bike innovation made in Japan: Continued development of e-bikes tailored specifically to the Japanese market is crucial. This could involve compact designs for navigating densely populated urban areas or models with features that cater to the specific needs of older riders. By focusing on such targeted innovation, the market can unlock further growth potential
- Technological leadership: Japanese manufacturers are well-positioned to be at the forefront of e-bike innovation. Their expertise in lightweight materials, coupled with a focus on developing lighter batteries, longer ranges and improved motor efficiency, will make e-bikes even more attractive to Japanese consumers. This technological leadership will not only solidify Japan's position within the global bicycle market but also ensure cycling remains a relevant and appealing transportation option for a wider demographic in the years to come

ASEAN

E-bikes — the catalyst for growth

- The rise of e-bikes has been a game-changer for the ASEAN bicycle market. The geography of Southeast Asia can be challenging, with hilly terrains in some regions and scorching temperatures in others. E-bikes provide the necessary assistance to navigate these terrains and combat the heat, making cycling a more accessible and comfortable option for a wider demographic. This is particularly appealing to individuals and families who may not have the fitness level for traditional bicycles
- Aligning with environmental consciousness: Growing awareness of environmental issues and the need for sustainable transportation options are the major trends across Southeast Asia. E-bikes, with their low carbon footprint, perfectly align with this growing consciousness. Governments and environmental groups are promoting e-bikes as a viable alternative to polluting vehicles, contributing to a cleaner and more sustainable transportation ecosystem
- Promoting inclusive cycling: E-bikes cater to individuals and families with varying fitness levels. This inclusivity makes cycling an activity that everyone can enjoy, fostering a sense of community and encouraging more people to participate in leisure and recreational cycling activities

E-bike industry volumes in ASEAN (calendar years 2019 to 2024)



Note: ASEAN includes Singapore, Malaysia, Indonesia, Thailand, Vietnam, Philippines and Rest of ASEAN countries

Source: Mordor Intelligence, CRISIL INTELLIGENCE

E-bike share in the ASEAN bicycle industry reached 17.1% in 2024 from 12.2% in 2019. Although slow, people in ASEAN countries have started switching to e-bikes. With some of the economies doing well, people are increasingly looking to spend on e-bikes, which are otherwise an expensive alternative to conventional bicycles. The ASEAN bicycle market witnessed a CAGR of 13.8% between 2019 and 2021, 9.9% between 2022 and 2024, and approximately 8.5% between 2019 and 2024.

Major global bicycle manufacturers

Accell Group

Accell Group, founded in 1998 and headquartered in Heerenveen, the Netherlands, is a manufacturer of bicycles, bicycle parts and accessories. It boasts a diverse portfolio of brands, including Babboe, Batavus, Diamondback, Ghost, Haibike, Koga, Lapierre, Raleigh, Sparta and Winora, with XLC serving as the brand for bicycle parts and accessories.

Utilising specialised retail outlets such as bike shops and exercise equipment stores, Accell Group caters to a broad spectrum of consumers seeking high-quality bicycles and related products. With a workforce of roughly 3,700 individuals spanning 15 countries, Accell Group operates on a global scale, distributing bicycles and associated products to dealers and consumers in over 80 countries. In 2023, the company faced challenges of accumulated inventory levels and slowdown in demand and hence a 10% on-year decline in revenue to EUR 1.3 billion.

Trek Bicycle Corporation

Trek Bicycle Corporation, founded in 1975 and headquartered in Wisconsin, the US, is a manufacturer and distributor of bicycles and cycling products, operating under brands such as Trek, Electra Bicycle Company, Bontrager and Diamant Bikes.

Currently, Trek Bicycle Corporation boasts a network of nearly 1,700 dealers throughout North America, with distribution extending across 90 countries globally. The majority of its manufacturing occurs outside the US, with production facilities located in countries such as China, Taiwan, the Netherlands and Germany.

PON Holdings BV

Pon Holdings BV, founded in 1980 and headquartered in Almere, the Netherlands, is a prominent family-owned multinational corporation, with 15,700 employees across 34 countries spanning six continents.

Pon Holdings is one of the largest mobility groups in the Netherlands, catering to millions of people with a comprehensive range of bikes, cars and mobility services. Its extensive premium brand portfolio sets it apart, encompassing over 20 bicycle brands distributed across Europe, North America, South America and Asia.

Pon.Bike, in 2023, despite the challenging economic environment, achieved total revenue of more than €10 billion. 2022 was a notable year for the company, driven by several acquisitions, notably Dorel Sports. This strategic move propelled Pon.Bike into a global market leader, boasting a portfolio of renowned brands such as Cannondale, Gazelle, Kalkhoff, Cervélo and Urban Arrow. The company operates in various locations, including the Netherlands, Australia, Germany, Brazil, the US, Canada, China and the UK.

Yamaha Motor Co. Ltd

Yamaha Motor Co. Ltd, founded in 1887 and headquartered in Shizuoka, Japan, is a diversified automotive company that manufactures and markets a wide range of products, including motorcycles, e-bikes, marine products, robotics, financial services and various components.

Yamaha Bicycle, a subsidiary of Yamaha Motor Co. Ltd, has played a pioneering role in the development of electrically powered bicycles, commonly known as “e-bikes." In 1993, Yamaha Motor introduced the world's first e-bike, featuring

its innovative Power Assist System (PAS). This system utilises an electric motor to provide assistance to the rider's pedalling efforts in a way that feels natural and harmonious with human movement.

Giant Manufacturing Co. Ltd

Giant Manufacturing Co. Ltd, founded in 1972 and headquartered in Taichung, Taiwan, is recognised as one of the prominent manufacturers and exporters of bicycles worldwide. Originating as an original equipment manufacturer (OEM) for Schwinn in the 1970s, the company launched its brand globally in the 1980s. It offers a comprehensive range of bicycles catering to various needs and preferences. Its product lineup includes on-road, x-road, off-road, youth and electric models, ensuring there is a suitable option for every type of rider.

In 2023 and 2024, it recorded total revenue of TWD 76.95 and TWD 71.25 billion from all the segments it caters to.

GIANT, a brand under the Giant Group umbrella, secured the prestigious Most Rated Bicycle Brand Award in Australia. It achieved this accolade in the bicycle brand category amidst stiff competition from nearly 20 other brands, emerging victorious among over 100 retail category projects.

Hero Cycles

Hero Cycles Ltd, founded in 1956, is India's largest bicycle manufacturer. It is currently headquartered in Punjab, India. As per the Guinness Book of Records 1989, Hero Cycles was the world’s largest bicycle manufacturer in 1986, supported by various ancillary units.

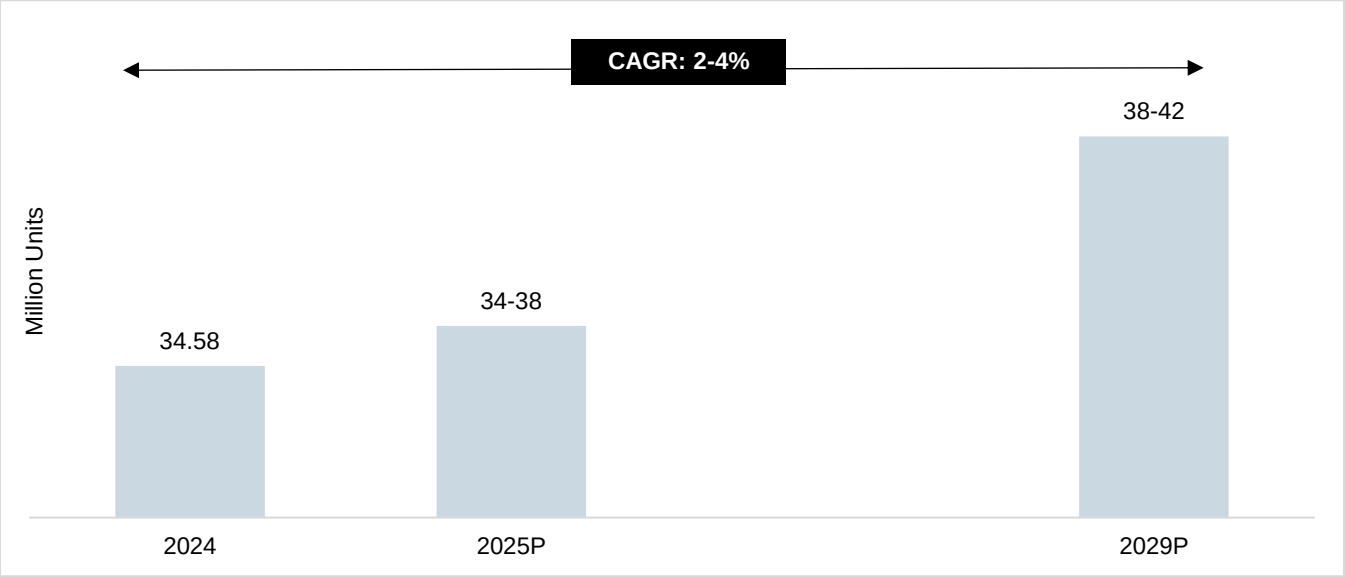
Hero Cycles has ventured into global markets by exporting to Europe and other regions. Furthermore, the company has embraced diversification by entering the electric and premium bicycle segments through strategic acquisitions of Avocet Sports, HNF and Firefox Bikes. This strategic move underscores Hero Cycles' adaptability and foresight in catering to evolving consumer preferences and industry trends. In fiscal 2024, Hero Cycles clocked total consolidated revenue of Rs. 1,900 crores from all segments, which was a 3.9% increase from fiscal 2023.

Hero Cycles has an annual manufacturing capacity of over 7.5 million bicycles, reflecting its dominant position in the Indian market, holding a commanding market share of over 43% in the country.

Recognising the shift in consumer preferences, it has begun venturing into the electric bicycle market. This strategic move aims to maintain its market leadership as e-bikes become increasingly popular not just in developed nations but also in India, where affordability remains a key concern. Some of the popular e-bike models manufactured by Hero Cycles are Hero Lectro C3, Hero Lectro H5, Hero Lectro’s range of F3i, F6i, C8i, F1 and F2i models.

Outlook of the global bicycle industry (2024 to 2029)

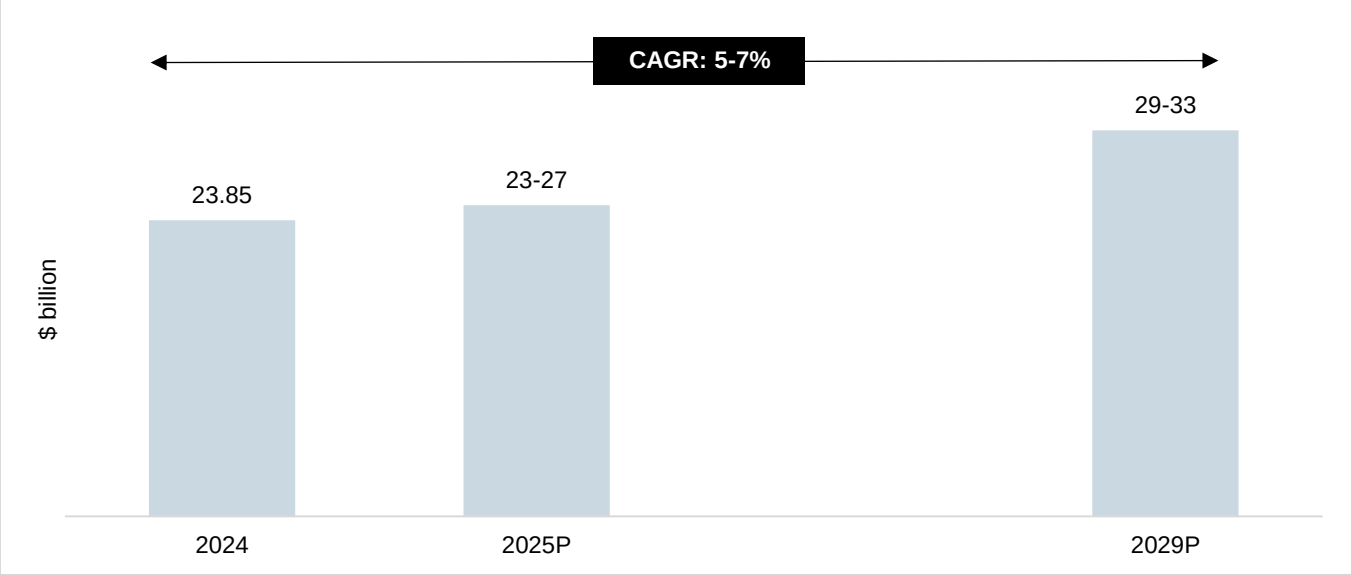
Overall bicycle market volume (calendar years 2024 to 2029)



Note: The above figures include bicycle market volumes for the US, Europe, Japan and ASEAN.

Source: Mordor Intelligence, CRISIL INTELLIGENCE

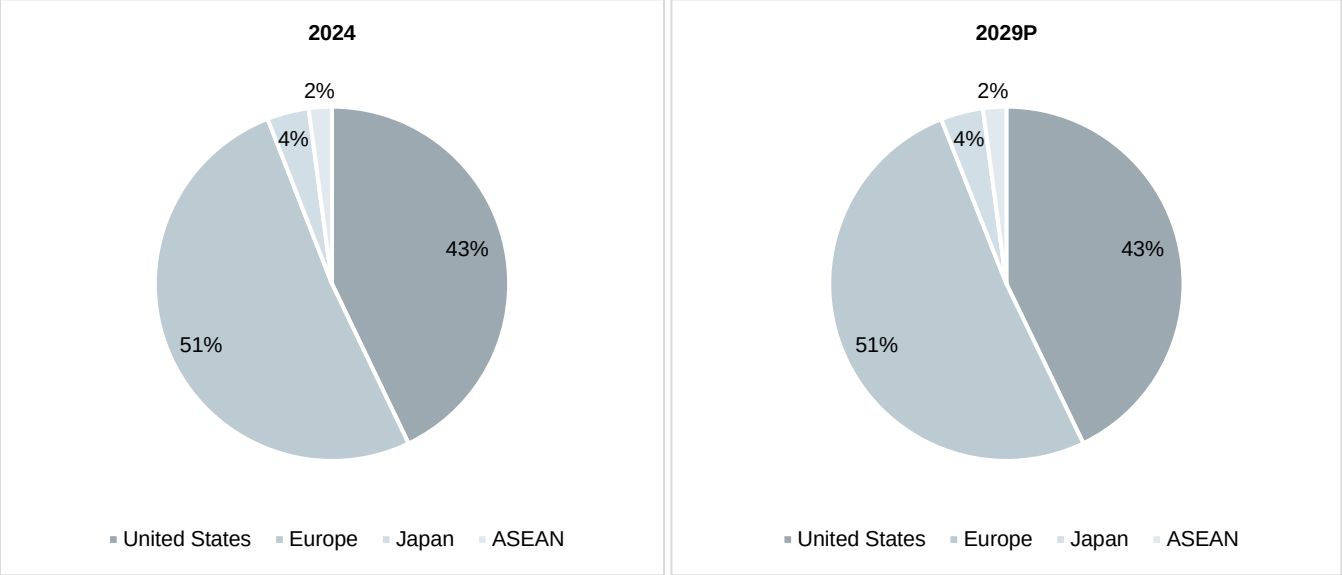
Overall bicycle market value (calendar years 2024 to 2029)



Note: The above figures include bicycle market value for the US, Europe, Japan and ASEAN.

Source: Mordor Intelligence, CRISIL INTELLIGENCE

Geography wise share in value terms ($ billion)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

Globally, more and more cyclists are taking to the roads. This market in value terms is poised to grow at a CAGR of 5-7% to $29-33 billion by 2029, with Europe contributing ~60% to the market. Europe's strong cycling culture makes it an attractive premium-priced market, with its e-bike sales expected to grow at a CAGR of 3.35% between 2024 and 2029 and reach 9-11 million units by 2030.

The global bicycle industry is poised for a period of dynamic expansion, fuelled by a confluence of environmental consciousness, health-driven lifestyles, and technological innovation. Between 2024 and 2029, it is expected to log a CAGR of 2-4% in volume terms and 5-7% in revenue terms, painting a promising picture of a burgeoning market. Some of the key reasons for the growth in the industry in the coming five years are as follows:

Environmental imperative: As environmental concerns take centre stage, bicycles are emerging as a champion of sustainable transportation. Consumers are increasingly opting for eco-friendly cycling over traditional modes of transport such as cars and public transit. This trend is further amplified by government initiatives that promote cycling infrastructure and green commuting policies.

Health and wellness: The growing emphasis on health and wellness is putting bicycles back in the spotlight. The numerous benefits of cycling, from improved cardiovascular health to stress reduction, are being widely recognised. This focus on well-being is making cycling an attractive option for a broader demographic.

Urban mobility solutions: Urbanisation and the ever-present challenge of traffic congestion are creating fertile ground for bicycle adoption. Bicycles offer a faster and more efficient way to navigate crowded city streets, especially when considering rising fuel prices. For many urban dwellers, cycling is becoming not just a leisure activity, but also a practical and cost-effective transportation choice.

Technological revolution: Advancements in e-bike technology, battery life, and affordability are opening the door to a whole new segment of riders. E-bikes are no longer a niche product; they are becoming mainstream, making cycling

accessible to those who might have previously found it too strenuous. This technological revolution is significantly expanding the market potential of the bicycle industry.

Investment surge: The cycling industry is attracting significant investor interest, leading to a surge in funding for innovative products and the expansion of retail networks. This influx of capital will fuel the development of new technologies, materials and design approaches, pushing the boundaries of the cycling experience.

However, a major reason for the growth is the evolution of e-bikes in many markets globally as consumer acceptance of e-bikes increases, thus supporting the bicycle industry to grow in terms of both volume and value. Following are some of the trends that the industry is experiencing and may continue to do so in the coming years, backed by technological advancements at regular intervals:

E-bike boom: The industry is bracing for an e-bike boom. E-bikes are expected to be the primary driver of growth, with sales projected to surpass traditional bicycles in some regions. The convenience and accessibility of e-bikes are a game changer, attracting riders of all ages and fitness levels.

Premiumisation takes the lead: Consumers are no longer satisfied with basic bicycles. There is a growing demand for high-quality bicycles with advanced features and top-of-the-line components. This trend towards premiumisation indicates a shift in how people perceive cycling, from a utilitarian mode of transport to a valued leisure activity and fitness tool.

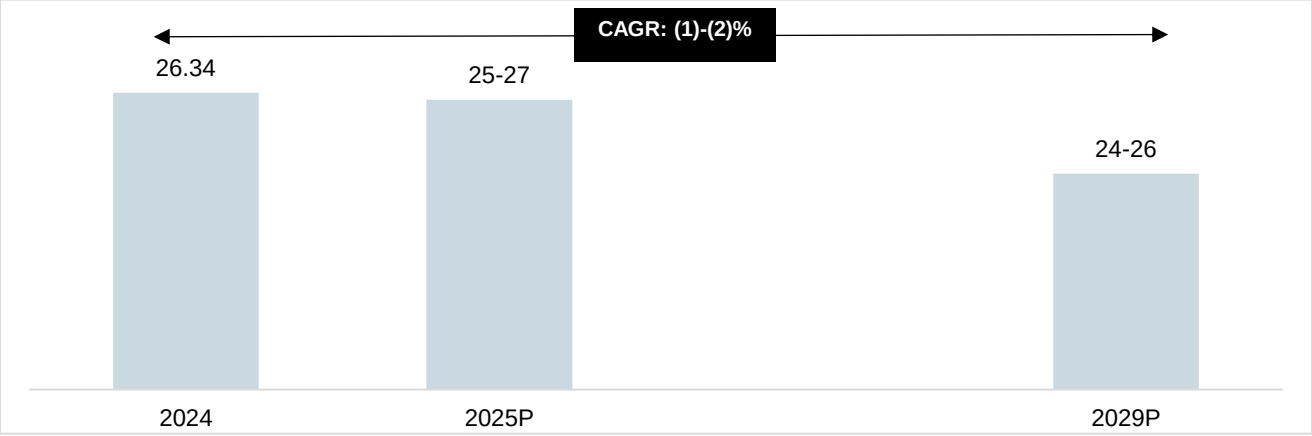
Direct-to-consumer (D2C) revolution: The rise of online platforms is disrupting the traditional brick-and-mortar retail model. D2C sales are expected to continue their upward trajectory, offering consumers more choice, competitive pricing, and potentially a more convenient shopping experience.

Data-driven cycling: Cycling is about to get a digital upgrade. The integration of sensors and connected technologies will transform bicycles into data-driven machines. Users can track their performance, navigate unfamiliar routes, and receive real-time maintenance alerts through their connected bike.

Outlook for the global bicycle industry by product type

Conventional bicycles

Conventional bicycle volume forecast (calendar years 2024 to 2029)



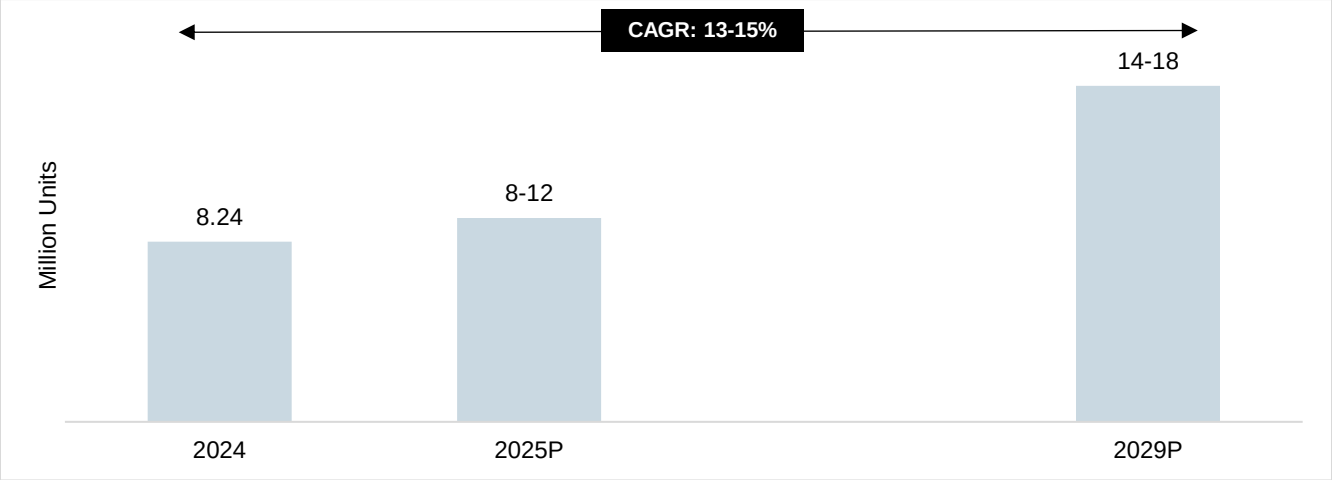
Note: The above figures include bicycle market volumes for the US, Europe, Japan and ASEAN.

Source: Mordor Intelligence, CRISIL INTELLIGENCE

The conventional bicycle segment is anticipated to witness de-growth between 2024 and 2029 as it may face competition from e-bikes, which are increasingly gaining market acceptance across different geographies. Conventional bicycles have several advantages such as affordability, health benefits and low maintenance, that help them conquer majority of the bicycle market but as the customer dynamics are at the helm of a change, they are anticipated to witness some pressure on volumes in the coming years. Their volume is expected to clock a CAGR of (1)-(2)% between 2024 and 2029, reaching to 24-26 million units.

E-bikes

Electric bicycle volume forecast (calendar years 2024 to 2029)



Note: The above figures include bicycle market volumes for the US, Europe, Japan and ASEAN.

Source: Mordor Intelligence, CRISIL INTELLIGENCE

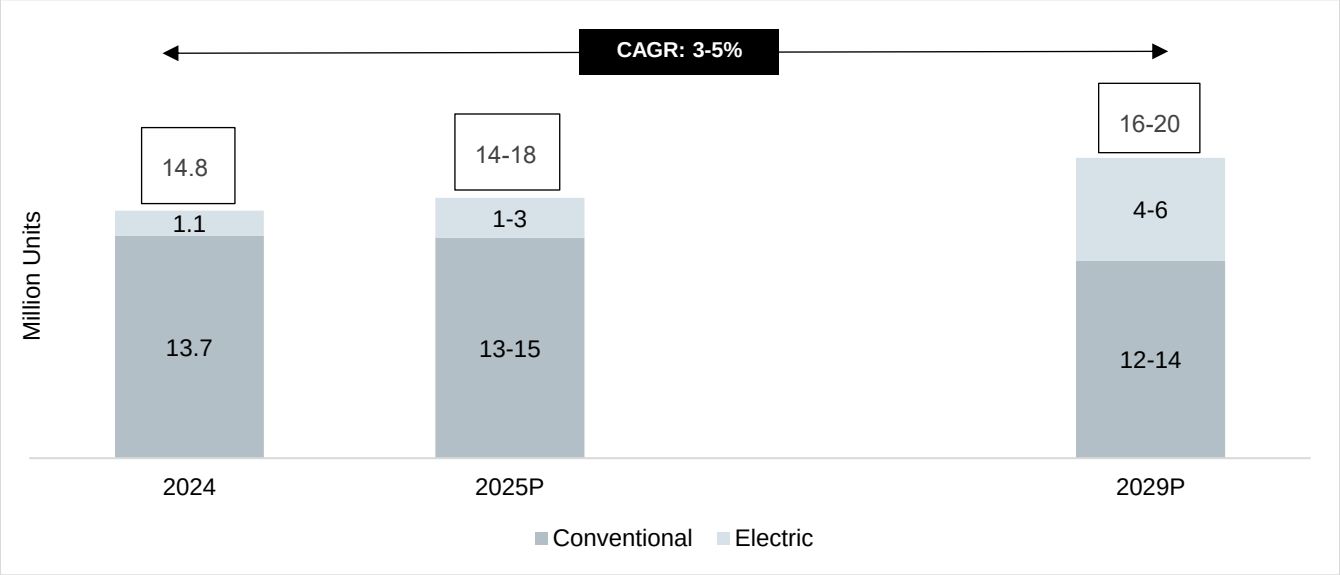
The future of cycling is electric. E-bikes are poised for good growth in global markets between 2025 and 2029, with market volume projected at 14-18 million units by 2029 (CAGR of 13-15%). Their broader appeal — easier to climb hills and travel longer distances — is attracting new demographics to cycling.

Additionally, e-bikes present an eco-friendly and efficient solution for urban commutes, potentially reducing traffic congestion. Government incentives and advancements in battery range and motor technology are further propelling this e-revolution. While growth rates might vary by region, the outlook for e-bikes is undeniably bright. Challenges such as regulations and battery limitations remain, but continued innovation and a focus on responsible use will solidify e-bikes' dominance in the global bicycle market for years to come.

Outlook for the bicycle industry by geography

United States

Overall bicycle market volume forecast for US (calendar years 2024 to 202930)



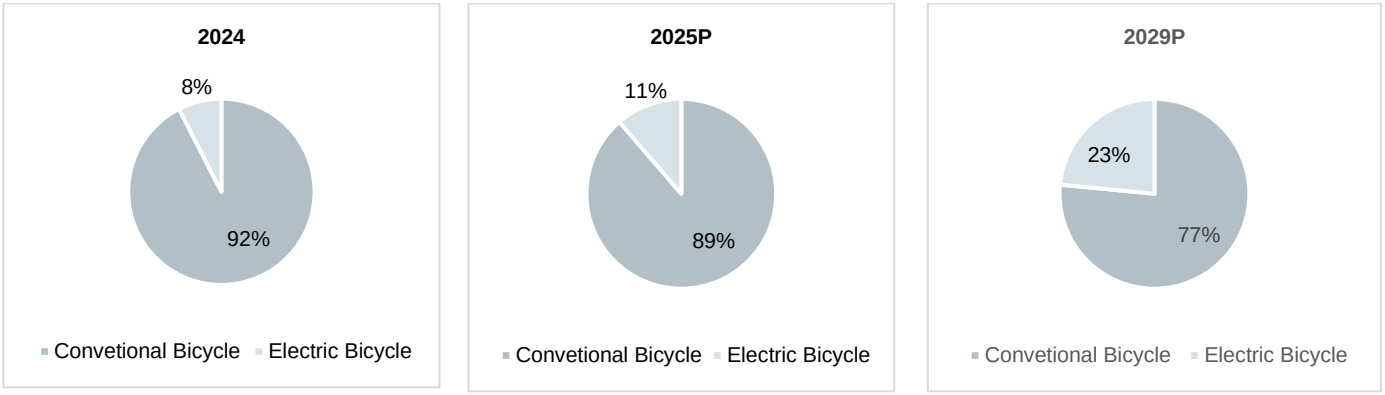
Source: Mordor Intelligence, Crisil Intelligence

The US bicycle market volume is expected to reach 16-20 million units (conventional and electric combined) in 2029, registering a CAGR of 3-5% between 2024 and 2029. In revenue terms, the CAGR for the same period is expected to be in the range of 4-6%. E-bikes in US may witness a CAGR of 32-34% between 2024 and 2029 as more people may increasingly prefer convenience over manual effort, with an anticipatory strong support from the government in terms of incentives.

The increase in the number of people who use a bicycle as a form of recreation is expected to expand the market during the forecast period. The preference for bicycles as a convenient way of exercising for fitness is expected to drive the market. Trendy mountain bikes and e-bikes are gaining the grip of the millennials in the US.

US retailers are referring to the benefits of bicycles to increase their sales, such as easy to pedal, fitness bound as it helps to manage heart health and stress. Also, as competition increases, manufacturers are forced to invest in R&D to create better bicycles. This could lead to improved battery technology, range and performance, making bicycles more accessible and appealing to a broader range of consumers.

Break-up of market share by product type in US (in million units)

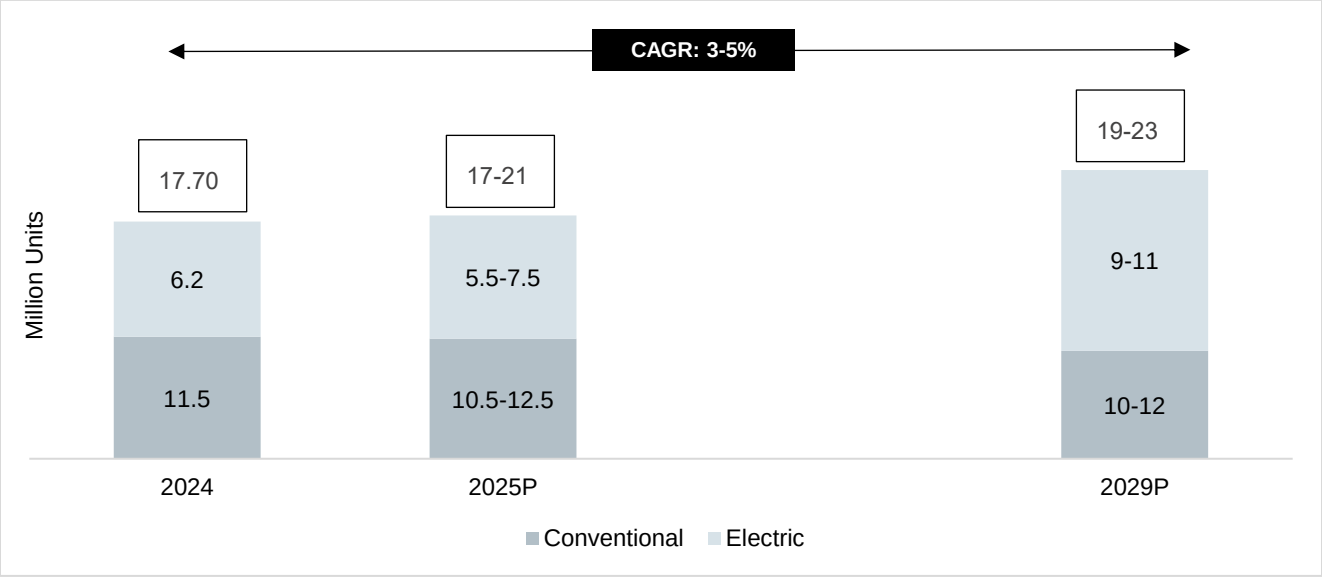


Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market share of conventional bikes in the US is anticipated to decrease 16% between 2024 and 2029, which will be added to the market share of e-bikes.

Europe

Overall bicycle market volume forecast for Europe (calendar years 2024 to 2029)

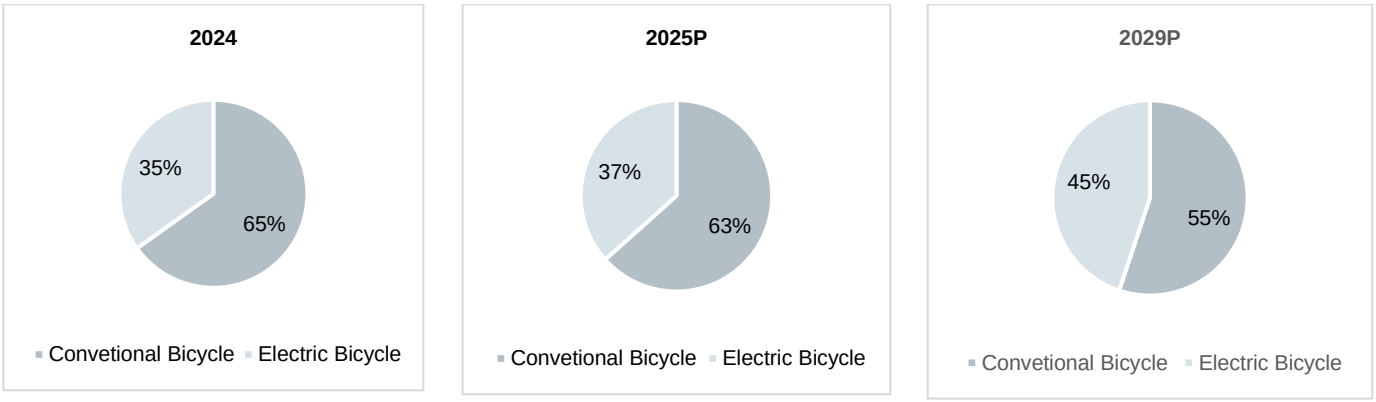


Source: Mordor Intelligence, CRISIL INTELLIGENCE

The European bicycle market is expected to continue its positive trajectory between 2024 and 2029, with market volume projected at 19-23 million units (conventional and electric combined) by 2029. This translates to a CAGR of 3-5%. In revenue terms, CAGR is expected to remain in the range of 4-7%. E-bikes in Europe may witness a CAGR of 9-11% between 2024 and 2029 owing to its wider adoption in the region. Several key drivers are propelling this expansion. Traffic congestion in European cities is a growing concern, prompting a significant shift towards alternative modes of transportation, with bicycles leading the charge. Furthermore, a rising focus on health and fitness, coupled with growing environmental awareness, is fuelling demand for bicycles as a means of exercise, recreation and sustainable commuting.

A key factor propelling this growth even further is the resurgence of e-bikes. These innovative bicycles with electric assist are attracting new demographics to cycling. E-bikes empower riders to conquer hills and longer distances with greater ease, making cycling a more accessible and attractive option for a wider range of people. With advancements in battery technology, e-bikes offer extended ranges and excellent performance, making them the preferred choice for urban commuting. This, combined with Europe's established cycling culture and well-developed infrastructure in many countries, creates a strong foundation for continued market expansion in the coming years.

Break-up of market share by product type in Europe (in million units)

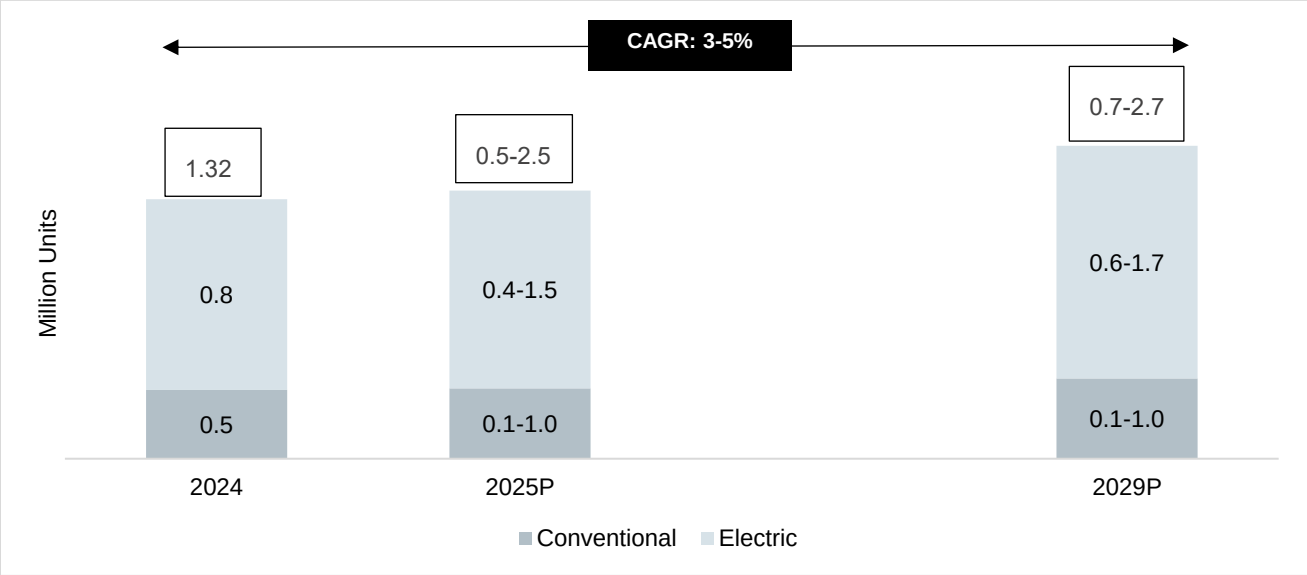


Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market share of conventional bikes in Europe is anticipated to reduce approximately 15% between 2024 and 2029, which will be added to the market share of e-bikes.

Japan

Overall bicycle market volume forecast for Japan (calendar years 2024 to 2029)



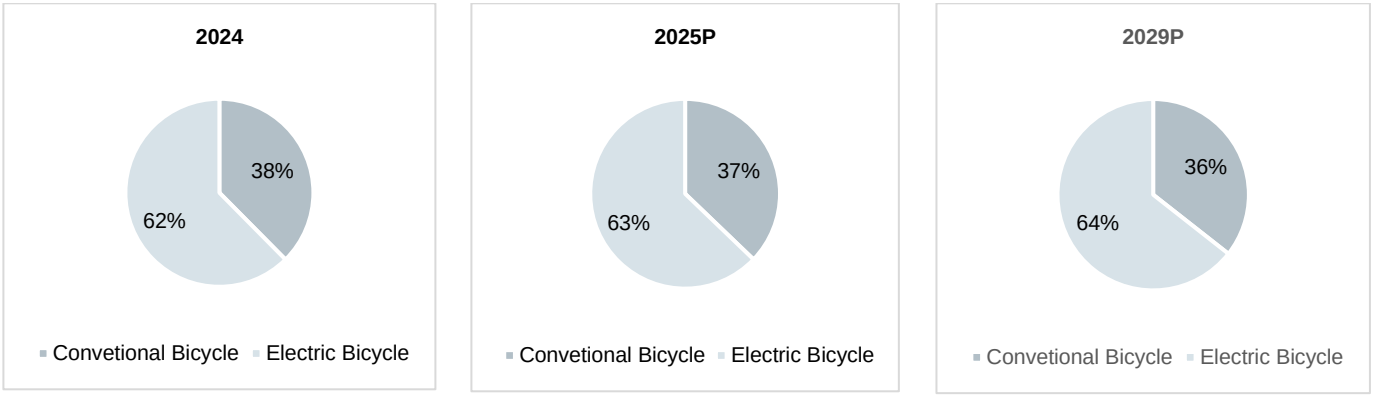
Source: Mordor Intelligence, CRISIL INTELLIGENCE

Japan's bicycle market is poised for a comeback between 2024 and 2029, shaking off recent declines and clocking a CAGR of 3-5%. By 2029, bicycle volume is expected to reach 0.7-2.7 million units (conventional and electric

combined). In revenue terms, CAGR is expected to remain in the range of 6-8% between 2024 and 2029. This moderate growth is fuelled by several factors. Urban congestion is prompting a shift towards bicycles for efficient commutes. A rising focus on health and environmental consciousness are making cycling a more attractive option for exercise and sustainable transportation. E-bikes in Japan may witness a CAGR of 4-6% between 2024 and 2029 and may remain in between 0.5-2 million units by 2029.

Additionally, e-bikes in Japan, like in other regions, could lure new riders seeking an easier way to navigate Japan's hilly terrain or longer commutes. While growth might be slower than in other markets due to the previous decline, Japan's established cycling culture, growing health and sustainability concerns, and the potential of e-bikes suggest a positive outlook for the coming years.

Break-up of market share by product type in Japan (in million units)

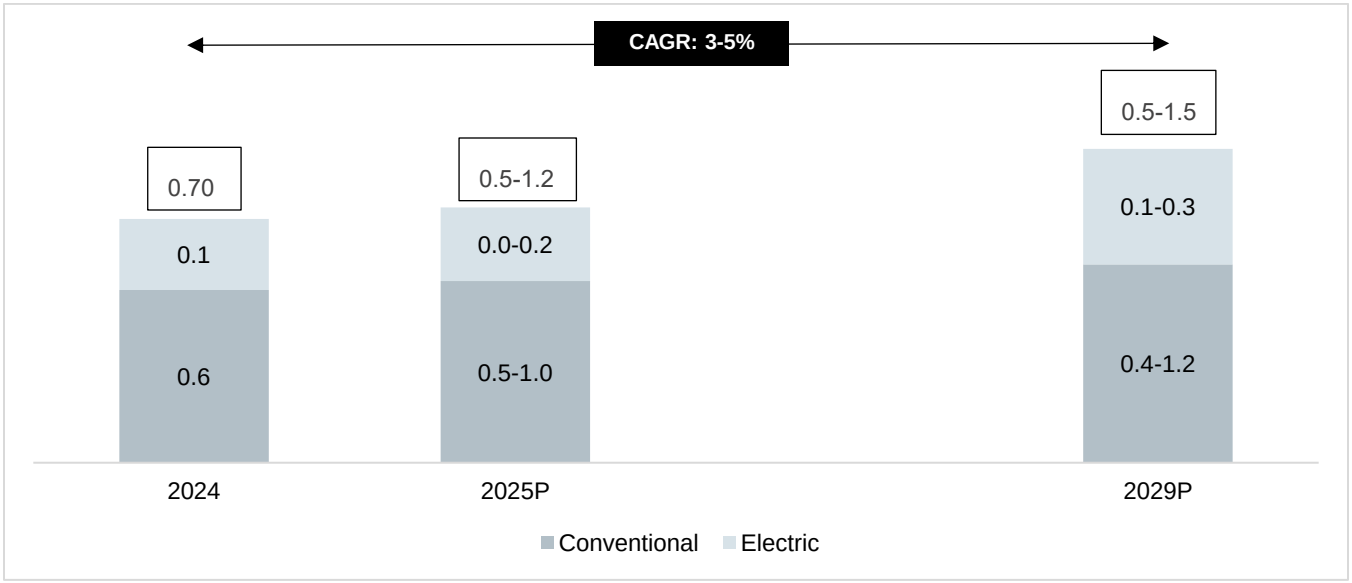


Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market share of conventional bikes in Japan is anticipated to reduce approximately 5% between 2024 and 2029, which will be added to the market share of e-bikes.

ASEAN

Overall bicycle market volume forecast for ASEAN (calendar years 2024 to 2029)



Note: ASEAN includes Singapore, Malaysia, Indonesia, Thailand, Vietnam, Philippines and Rest of ASEAN countries
Source: Mordor Intelligence, CRISIL INTELLIGENCE

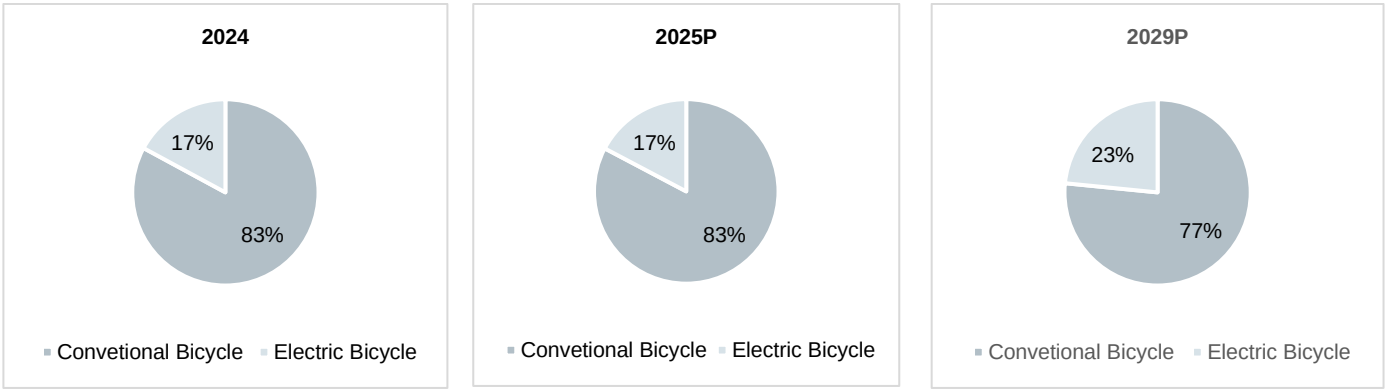
The outlook for the ASEAN bicycle market between 2024 and 2029 paints a picture of steady growth, albeit at a more modest pace compared to a few other regions. The ASEAN bicycle market's volume is anticipated to log a CAGR of 3-5%, reaching 0.5-1.5 million units by 2029. In revenue terms, the market is expected to clock a CAGR of 3-5%. E-bikes in ASEAN may witness a CAGR of 10-12%, with volumes remaining between 0.1-0.5 million units.

As cities in ASEAN continue to expand, traffic congestion is becoming a pressing concern. Bicycles offer a reliable and cost-effective solution for shorter commutes. Also, disposable income is on the rise, and people in ASEAN nations might have more resources to invest in bicycles for recreation and fitness. There is also increased support from governments as they have been promoting cycling through infrastructure development and awareness campaigns, potentially boosting the market.

Unlike in developed markets, the evolution of e-bikes in the ASEAN region has not yet picked up pace. However, they have the potential to gain traction, particularly for riders in hilly areas or those seeking a less strenuous commute.

There are also a few challenges that have kept the bicycle market's volume low in this region. Many ASEAN countries lack dedicated cycling infrastructure, which deters potential riders. Also, bicycles in the region are not perceived as a viable mode of transportation, thus restricting consumers' desire to switch to bicycles/e-bikes. Despite challenges, growing focus on urban mobility solutions, rising disposable income, and the potential of e-bikes suggest a positive, though measured, outlook for the bicycle market in ASEAN between 2024 and 2029.

Break-up of market share by product type in ASEAN (in million units)



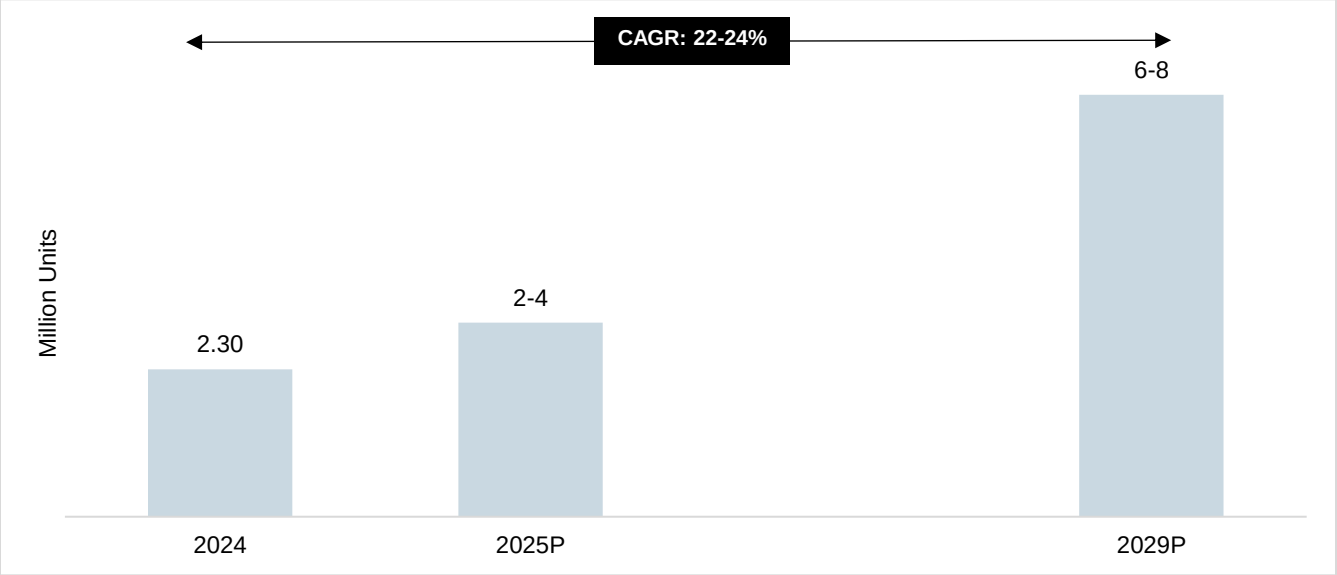
Note: ASEAN includes Singapore, Malaysia, Indonesia, Thailand, Vietnam, Philippines and Rest of ASEAN countries
Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market share of conventional bikes in ASEAN is anticipated to reduce approximately 7% between 2024 and 2029, which will be added to the market share of e-bikes.

Outlook for the bicycle industry by motor type

Mid-drive motor

Mid-drive motor volume forecast (calendar years 2024 to 2029)



Note: The above figures include bicycle market volumes for the US, Europe, Japan and ASEAN.

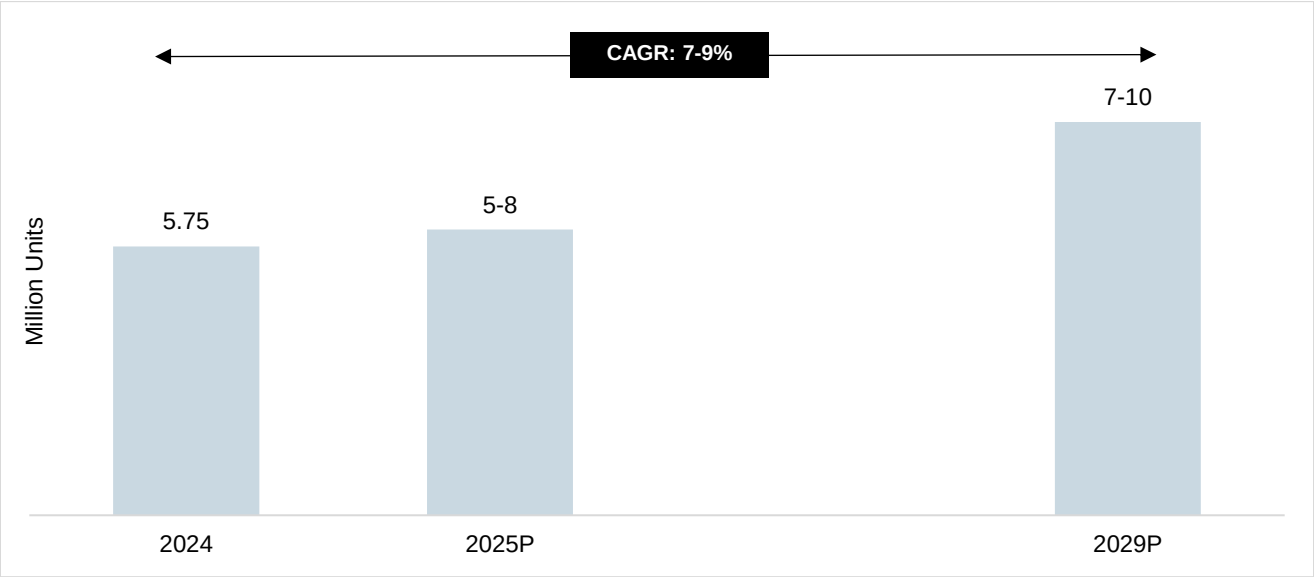
Source: Mordor Intelligence, CRISIL INTELLIGENCE

Mid-drive motors are poised to dominate the global e-bike market (2024-29) across various terrains. Their natural riding experience, efficiency and performance on diverse landscapes make them a popular choice for riders of all styles. Advancements in motor technology further solidify their dominance. The US market, fuelled by a growing preference for e-mountain biking and recreational cycling, is expected to see a surge in mid-drive motor e-bikes. In Japan's hilly regions, these motors will likely gain traction for their ability to conquer slopes. While cost might initially hinder their widespread adoption in ASEAN, potential exists for increased affordability and recognition of their benefits. Finally, Europe, with its established cycling culture and preference for high-performance e-bikes, will likely continue to favour mid-drive motors due to their superior technology and efficiency. Despite regional variations, mid-drive motors are poised to lead the e-cycling revolution in the coming years.

By 2029, their volume is expected to reach 6-8 million units, at a CAGR of 22-24%. While volume of mid-drive motors remains lower than that of hub motors, mid-drive motors will easily surpass hub motors in value terms owing to their higher cost.

Hub motor

Hub motor volume forecast (calendar years 2024 to 2029)



Note: The above figures include bicycle market volumes for the US, Europe, Japan and ASEAN.

Source: Mordor Intelligence, CRISIL INTELLIGENCE

Hub motors are expected to register growth between 2024 and 2029. Their budget-friendly price tag makes them an attractive entry point for cost-conscious riders globally, particularly in regions such as ASEAN with limited disposable income. The simpler design also offers easier maintenance for some riders. While the US and Japan, with their focus on performance cycling, might see slower adoption of hub motors, they could still be a viable option for casual riders or those in flatter areas. Even in Europe, where high-performance e-bikes reign supreme, hub motors might retain some appeal for budget-conscious recreational riders. Overall, affordability and simpler design will ensure hub motors remain a relevant player, especially in budget-conscious markets, despite facing potential challenges from increasingly affordable mid-drive motors in the coming years.

By 2029, their volume is anticipated to reach 7-10 million units, at a CAGR of 7-9%. While hub motors may continue to witness healthy volume compared to mid-drive motors, their price point will keep them below mid-drive motors when looked at from a value perspective.

5. Review of the Indian bicycle industry

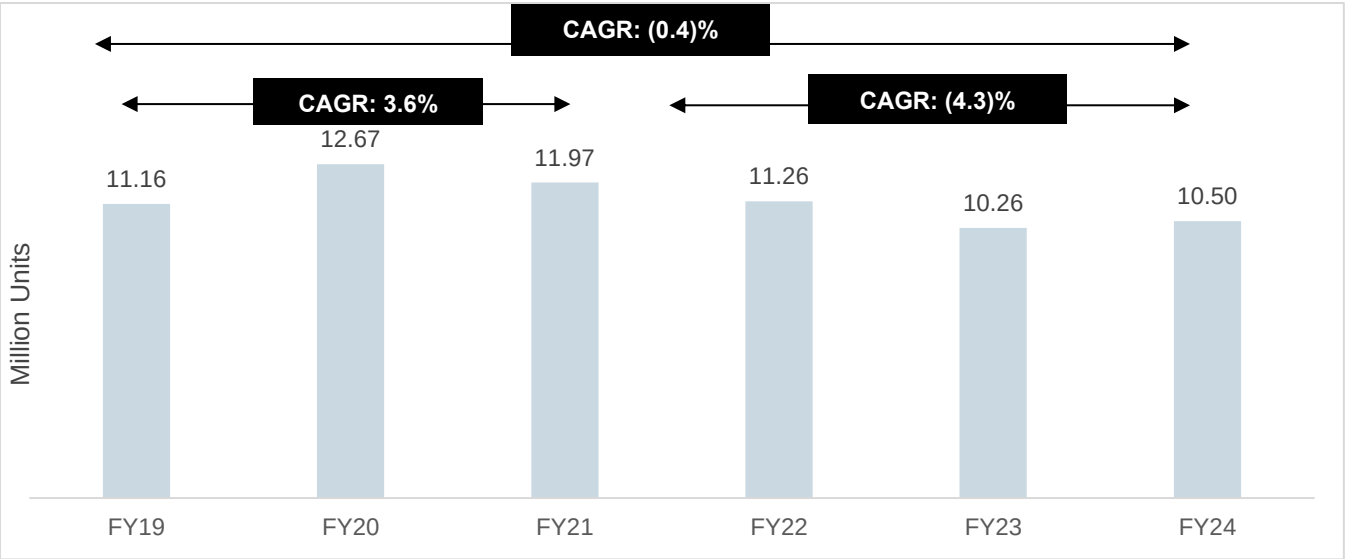
Review of the Indian bicycle industry (fiscals 2019 to 2024)

The success of the Indian bicycle industry can be attributed to its core strength: affordability and utility. Bicycles remain the backbone of transportation for millions in rural India, offering a reliable and economical way to commute, run errands and carry goods. This practicality extends to smaller towns and even Tier 2 and Tier 3 cities, where bicycles are seen as a viable alternative to congested public transport or expensive fuel-based vehicles.

The future of the Indian bicycle industry is brimming with exciting possibilities. The e-bike segment is witnessing significant growth, offering a convenient option for longer commutes or hilly terrains. These pedal-assisted bicycles are poised to revolutionise urban cycling, especially for those seeking a comfortable and eco-friendly mode of transportation. Additionally, technological advancements are shaping the future with lightweight materials, innovative gear systems, and even connected bicycles that enhance user experience and attract new demographics. Manufacturers are also focusing on design and functionality, catering to a style-conscious consumer base with bikes that are not just practical but also aesthetically pleasing.

Historical production development (fiscal 2018 to 2024)

Review of Indian bicycle (conventional) industry's sales volume



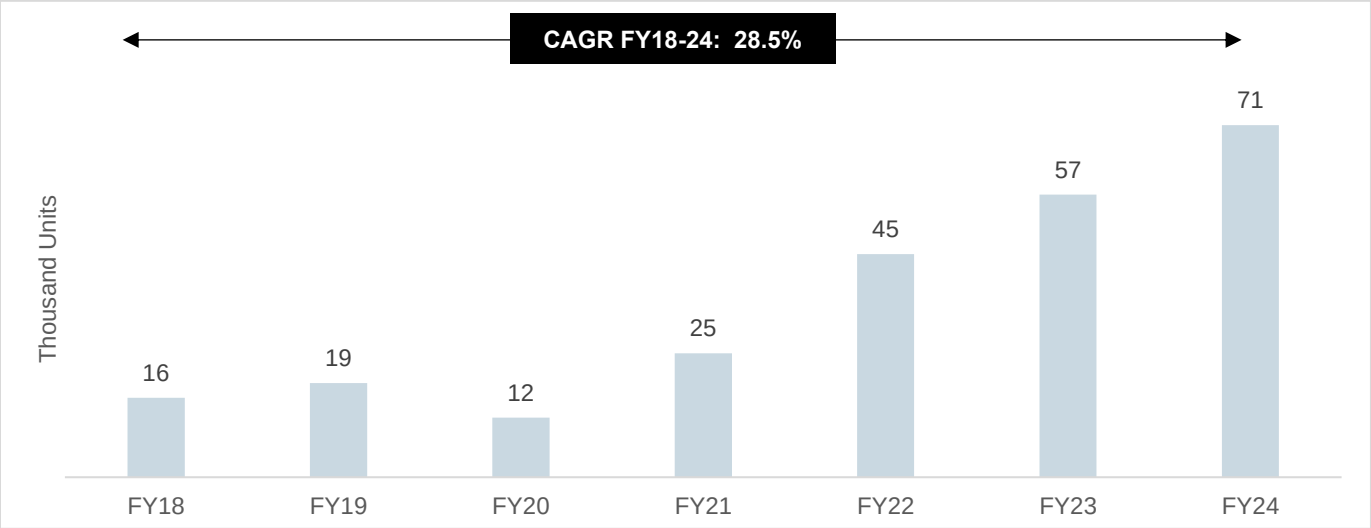
Source: Mordor Intelligence, CRISIL Intelligence

Between fiscals 2018 and 2024 the Indian bicycle industry's sales volume logged a negative CAGR of 0.4%. It reached 10.50 million units in fiscal 2024. Covid-19, unlike for other industries, helped the bicycle industry with added demand as many people switched to healthy lifestyle amidst the pandemic fear. Manufacturers, in anticipation of continuity of demand post Covid-19, were prepared as far as production was concerned, but the retail numbers did not meet manufacturers' expectations as the industry started witnessing a downturn in demand. The industry is still on its way to match the highs of fiscals 2020 and 2021.

Electrification in bikes

The Indian bicycle industry, traditionally dominated by pedal-powered models, is undergoing a transformation in electrification. Concerns about rising fuel costs, environmental impact and growing urban congestion have sparked a surge in e-bikes. Government initiatives such as the FAME scheme offering subsidies on electric bicycles have further fuelled this trend. Advancements in battery technology with lighter, longer-lasting options have also enhanced the appeal of e-bikes. While still in early stages compared with developed nations, the Indian e-bike market is projected for significant growth, driven by a focus on affordable options, diverse product categories and a rising online sales presence. However, challenges such as limited charging infrastructure and the need for consumer education remain.

Review of electric bicyles in the Indian bicycles industry



Note: The above figures include domestic and export sale volume
Source: Mordor Intelligence, CRISIL Intelligence

Electric bicycles is still a very niche category in the Indian market since consumers are price-sensitive; moreover, the road infrastructure needs further alignment to embed bicycling as a trend. E-penetration has hovered at 0.1-0.8% between fiscals 2018 and 2024.

The evolution of e-bicycles is gradually outpacing the demand for traditional bicycles since it minimizes human effort by 70-80%. As the industry innovates, several other factors can help drive e-bike's growth. These include the following:

Rising trend in fuel costs

The sheer affordability of EV adaption is leading to soaring e-bike sales in India. For decades, a vast majority of the Indian population has relied on two-wheelers or scooters as an affordable option for personal mobility. However, the exponential rise in the cost of petrol has pushed customers to switch to electric two-wheelers. E-bikes offer a compelling alternative – they are significantly cheaper to run compared with fuel-powered vehicles, reducing the financial burden on consumers.

Technology integration for new-age customers

In today's digitally driven world, e-bikes are increasingly being integrated with new-age technologies to supplement evolving customer needs. The modern e-bikes are becoming a game-changer in the advanced and greener world. Apart from boasting a futuristic design, the e-bikes are also backed by a range of data-driven technologies.

Technological integration is critical for the success of electrification in the Indian bicycle industry, particularly for attracting new-age customers, for a few key reasons:

Enhanced user experience: Technology can significantly improve the user experience with e-bikes. E-bikes offer features such as:

Connectivity: Integration with smartphones allows riders to track rides, monitor battery levels, and access navigation assistance

Smart features: E-bikes can be equipped with features like pedal-assist modes, adjustable power levels and built-in lights for increased safety and comfort

Anti-theft measures: GPS tracking and remote locking systems can enhance security and provide peace of mind for new-age customers who may be hesitant to leave their e-bikes unattended

Appeal for tech-savvy consumers: New-age customers are often tech-savvy and expect a seamless integration between their devices and the products they use. Advanced features and connectivity cater to this desire for a technologically integrated experience

Data-driven innovation: By collecting data on user behaviour and preferences through e-bikes, manufacturers can gain valuable insights to improve future models and personalise the e-bike experience for new-age customers.

Key players in the Indian bicycle market

Type	Brands	Description
Established players	Hero Cycles	Dominating the Indian market, Hero Cycles boasts a diverse product portfolio encompassing an extensive range of bicycles catering to various consumer segments
	TI Hercules Cycles	TI Hercules Cycles is a heritage brand known for its robust construction and reliability
	Avon Cycles	Recognised for embracing innovation, Avon Cycles offers a variety of bicycles catering to performance, comfort, freestyle riding, and children
	Atlas Cycles	Renowned for durability and value proposition, Atlas Cycles offers a wide range of bicycles for various applications
Emerging players	Ninety One Cycles	Ninety One Cycles positions itself as a modern and innovative brand, appealing to a younger generation of cyclists who value design, performance and a seamless online buying experience
	Rockstar Cycles	Rockstar Cycles carves a niche for itself by catering to the budget-conscious adventure cyclist

	Mojospin Cycles	Mojospin Cycles is a relatively new player in the Indian bicycle industry, having emerged in recent years

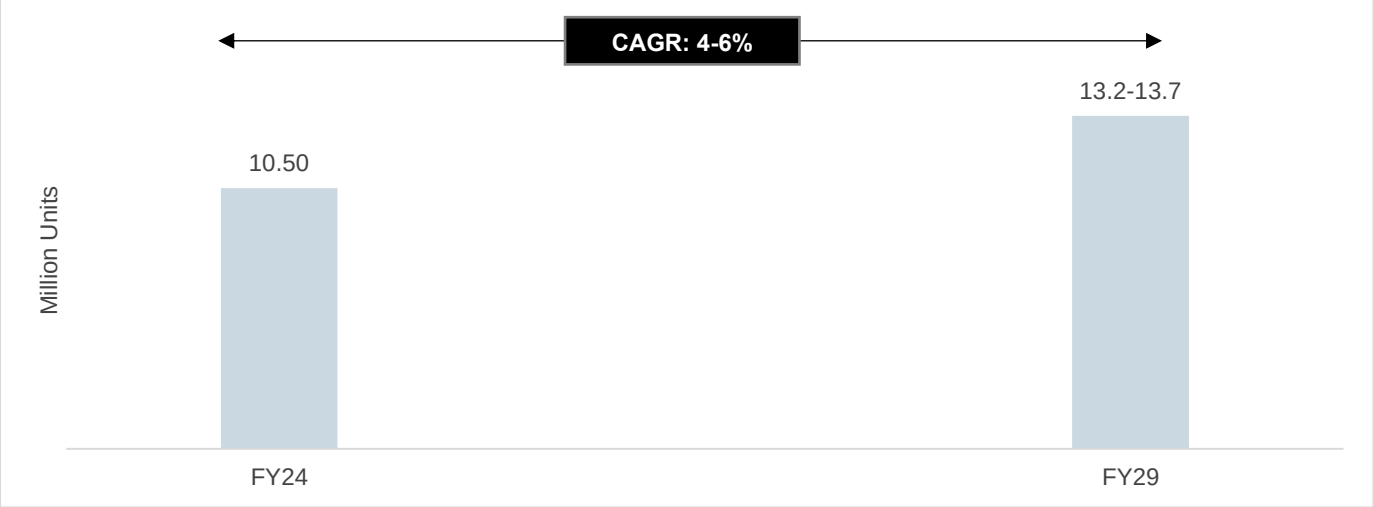
Note: Hero Cycles have options both in conventional as well as electric variants. Other mentioned manufacturers majorly caters to conventional buyers in India.

All the above brands have a different set of offerings for specific target customers. Below is the detailed information on the established players in the Indian bicycle industry.

Outlook of the Indian bicycle industry (fiscals 2024 to 2029)

Sales outlook of the organised market in India

Outlook of domestic Indian bicycle (conventional) industry sales volume

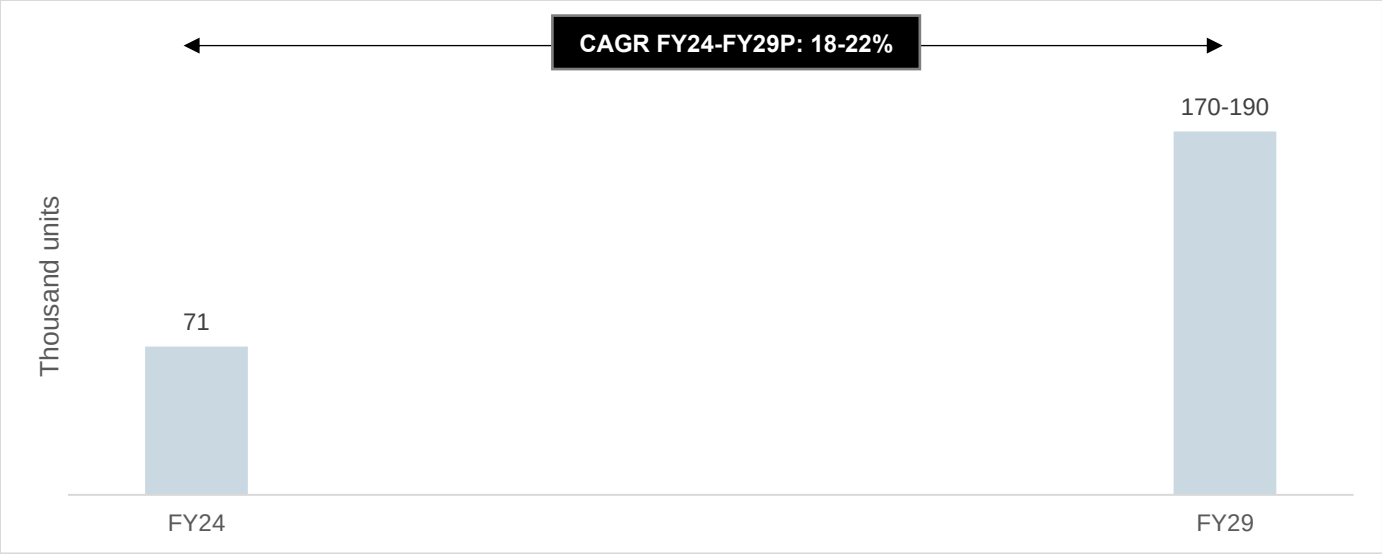


Source: Mordor Intelligence, CRISIL Intelligence

The Indian bicycle industry is expected to grow at a decent pace from fiscal 2024 to fiscal 2029. Several factors are projected to contribute to this upward trajectory. One key driver is the growing national emphasis on health and fitness. As the health benefits associated with cycling gain wider recognition, a corresponding rise in demand for bicycles designed for fitness and recreational purposes is expected. Furthermore, urbanisation and the concurrent need for environmentally friendly transportation solutions are poised to play a significant role. As Indian cities continue to expand, the demand for convenient and sustainable alternatives to automobiles and public transportation is expected to surge. Bicycles offer a healthy and eco-friendly mode of transportation, contributing to reduced air pollution and traffic congestion. Government initiatives that promote cycling infrastructure and green transportation initiatives will further fuel this growth.

Amid the requirement to improve on the innovation and infrastructure fronts, the Indian bicycle industry is expected to grow at 4-6% CAGR between fiscals 2024 and 2029, with volumes reaching 13.2-13.7 million units.

Estimated sale volume of electric bike in India by fiscal 2029



Note: The above figures include domestic and export sale volume
Source: Mordor Intelligence, CRISIL Intelligence

The electric bike industry in India is expected to log a CAGR of 18-22%, reaching 170-190 thousand units by FY2029. In revenue terms, the market is expected to clock a CAGR of 25-30% between FY2024 and FY2029 and stand at Rs. 6.5-7.5 billion by FY2029. Electric penetration in Indian bicycle industry is expected to be 0.7-0.9% in fiscal 2025; the penetration may be at 1.2-1.5% in fiscal 2029. Going ahead in the next five years, realization per unit may go up as premiumisation in the industry is expected to gain acceptance amongst customers.

Impact of regulatory changes on the Indian cycle market

Cycle reflector law

The cycle reflector law mandates bicycles must be equipped with front and rear reflectors. These reflectors should be strategically placed to maximise visibility, ensuring that both oncoming and trailing vehicles can spot cyclists.

The government's decision to make BIS (Bureau of Indian Standards)-certified reflectors mandatory on bicycles from January 1, 2023, was later followed by an extension of 6 months with all guidelines remaining unchanged. Though manufacturers have been mandated to comply with this law, there have been some differences among the manufacturers and the All India Cycle manufacturers' association because of which the decision has been implemented leniently. However, efforts are being made to penalise manufacturers in case of non-compliance since as the law's objective is to ensure the rider's safety.

Potential upcoming PLI schemes for the bicycle industry

Government is considering a PLI scheme for the cycle sector, especially for e-bikes, to support their manufacturing in India without being reliant on any other country for sourcing of raw materials, auto-components, etc. A PLI scheme will boost the production of e-cycle components, making India a hub for the technology powering these vehicles worldwide.

6. Review and outlook of the global ATV industry

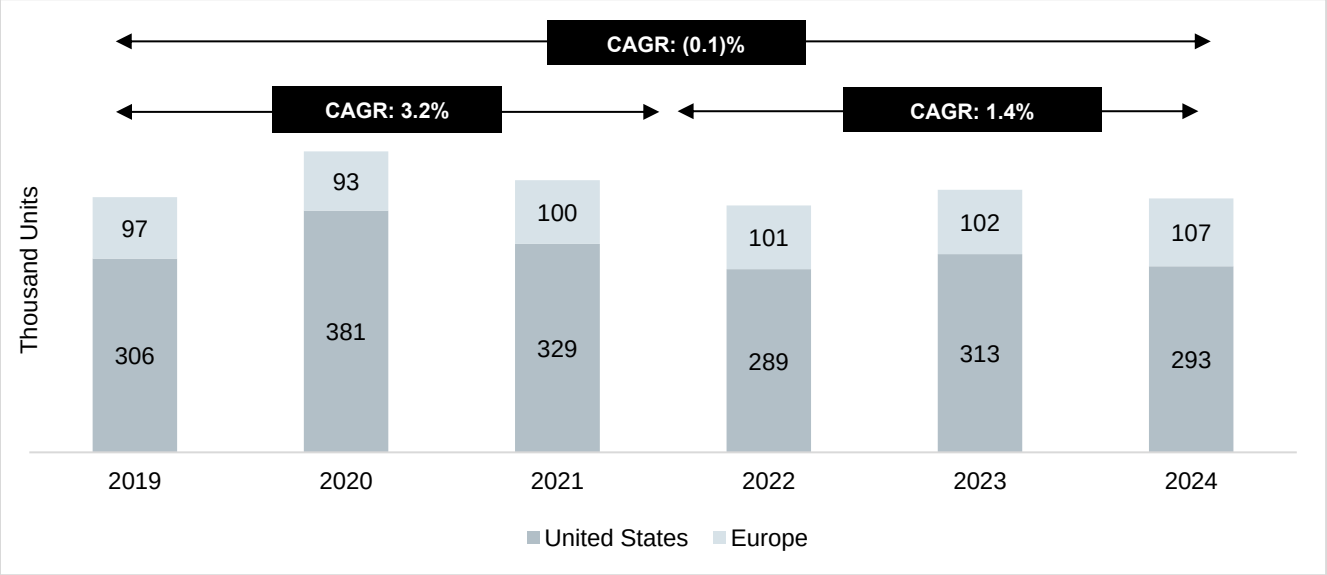
Review of the global ATV industry (calendar years 2019 to 2024)

ATVs excel in an array of applications, ranging from recreational pursuits such as hunting, fishing and exploration, to vital roles in search-and-rescue operations. Their manoeuvrability and proficiency in navigating rugged landscapes make them an invaluable asset. The flourishing recreational sector, with its emphasis on adventure sports and off-road activities, has fuelled demand for ATVs, particularly among younger demographics. Within the agricultural sector, ATVs have become a workhorse, effectively replacing manual labour for tasks such as crop spraying, livestock herding and equipment transportation. Even the military has embraced the utility of ATVs, employing them for reconnaissance, patrolling and troop transport in difficult terrain.

The global ATV market is poised for continued expansion driven by several key demand drivers. Rising disposable income, particularly evident in developing economies, empowers consumers to invest in leisure activities such as ATV riding. The burgeoning tourism sector, with its focus on adventure travel, creates a demand for ATV rentals and tours in scenic locations. Additionally, increased military spending in certain regions could translate to a higher demand for ATVs for military applications.

Historic production development (2019-2024)

Review of global ATV sales volumes



Note: Above figures comprise of sales for United States and Europe

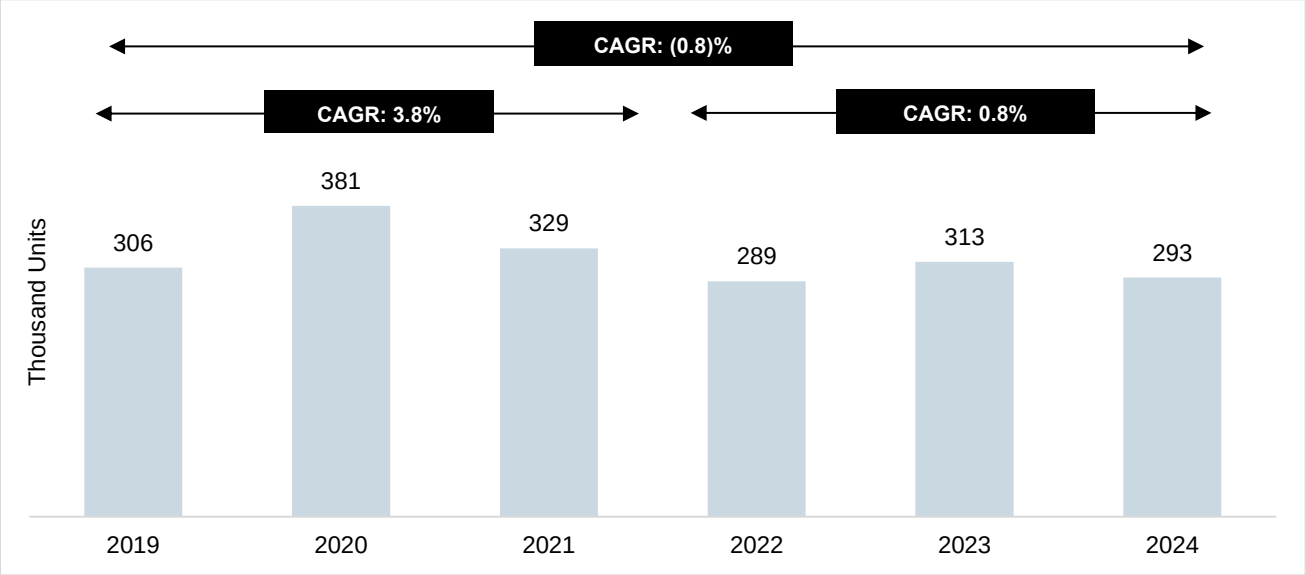
Source: Mordor Intelligence, CRISIL INTELLIGENCE

During the period 2019-21, ATV industry witnessed a CAGR of 3.2%, which further took a hit during the latter half where industry saw a modest growth of 1.4% between 2022-24. Overall, between 2019-24, industry witnessed a CAGR of (0.1)%. United States has been the major contributor to the demand of ATV (All-Terrain Vehicles)

Global ATV sales by geography

United States

Review of United States ATV sales volumes



Source: Mordor Intelligence, CRISIL INTELLIGENCE

During 2019-24, the industry grew at (0.8)% CAGR in the US. Key industry drivers included the benefits of using ATVs in agriculture, sports, recreation and military. These serve as the significant determinant for the growth of the ATV market in the country. The total expenditure on recreation in the United States touched $507.8 billion in 2022 compared with $ 447.3 billion in 2021, recording 13.3% on-year growth between 2021 and 2022.

Following are some of the features driving the ATV industry in the United States:

Demand for ATVs in United States: With the increasing popularity of outdoor sports in the US, demand for ATVs has been gaining traction in the country in recent years owing to their usage in outdoor recreational activity, hunting, snow plowing, killing weeds, camping, winching, field plowing, lawn/field mowing, etc.

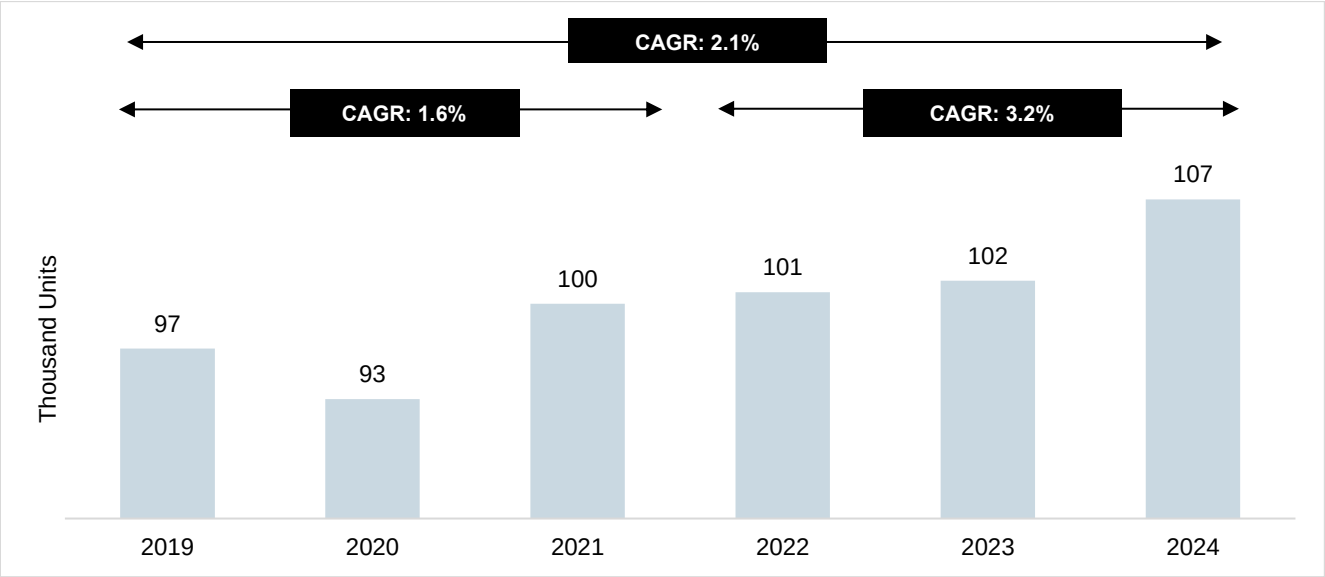
According to the Sports and Fitness Industry Association, the share of population who took part in outdoor sports in the US comprised 57.3% in 2023 compared with 55.0% in 2022.

Consumer demographics: Many ATV-owning individuals in the US have an annual household income of $65,000 or more. Polaris, Yamaha, and Honda are widely popular among consumers. A majority share of Honda and Polaris ATV owners live in rural areas.

Recent developments: In August 2023, Honda announced the launch of three new ATV models in the United States: the FourTrax Recon, the TRX250X, and the TRX90X. The FourTrax Recon, equipped with a 229-cc engine, attracts a starting price of $4,799.

Europe

Review of Europe ATV sales volumes



Source: Mordor Intelligence, CRISIL INTELLIGENCE

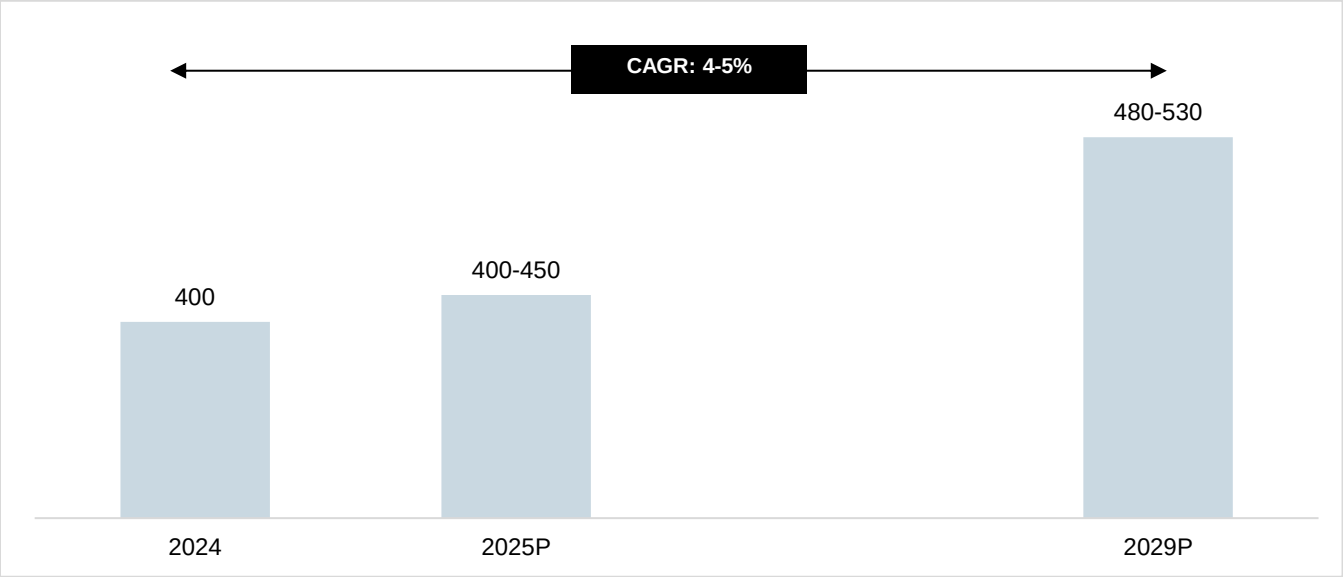
During 2019-24, the ATV industry in Europe grew at 2.1% CAGR. The use of ATVs in Europe has been significantly boosted by recreational activities and agricultural, and landscaping operations. Numerous nature parks have integrated these vehicles into activities such as horticulture, herding and timber cutting. Since most ATVs are not permitted to be operated on highways and other main roads, government authorities across the region have increased the budgetary allocations to build new off-road trails that may be helpful for recreational enthusiasts and boost adventure sports activities in the region. This is expected to have a positive impact on the market.

Popular players and brands

Country	Brands
US	Polaris
	Can-Am
	Honda
	Yamaha
	Kawasaki
Europe	CFMOTO
	BRP (Can-Am)
	Yamaha
	Polaris

Outlook of the global ATV industry (calendar years 2024 to 2029)

Outlook of ATV sales volumes (2024-2029)



Note: Above figures comprise of sales for United States and Europe

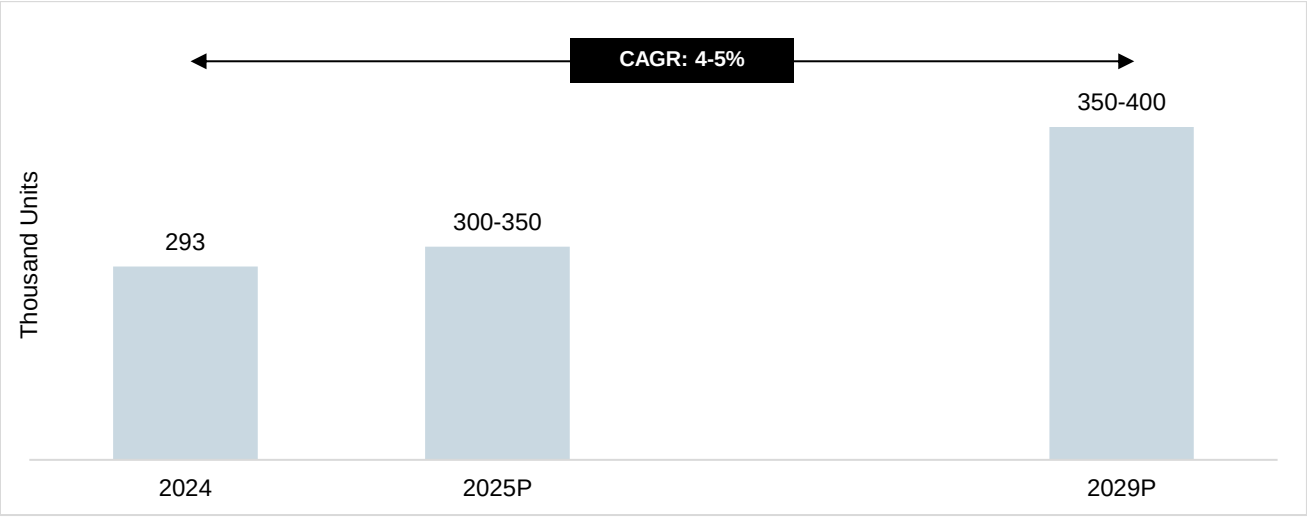
Source: Mordor Intelligence, CRISIL INTELLIGENCE

Overall, the industry is expected to grow at 4-5% CAGR from 2024 to 2029 period, with volumes reaching up to 480-530 thousand units, for both the US and Europe geographies.

Outlook of global ATV sales by geography

United States

Outlook of US ATV sales volumes (2024-2029)



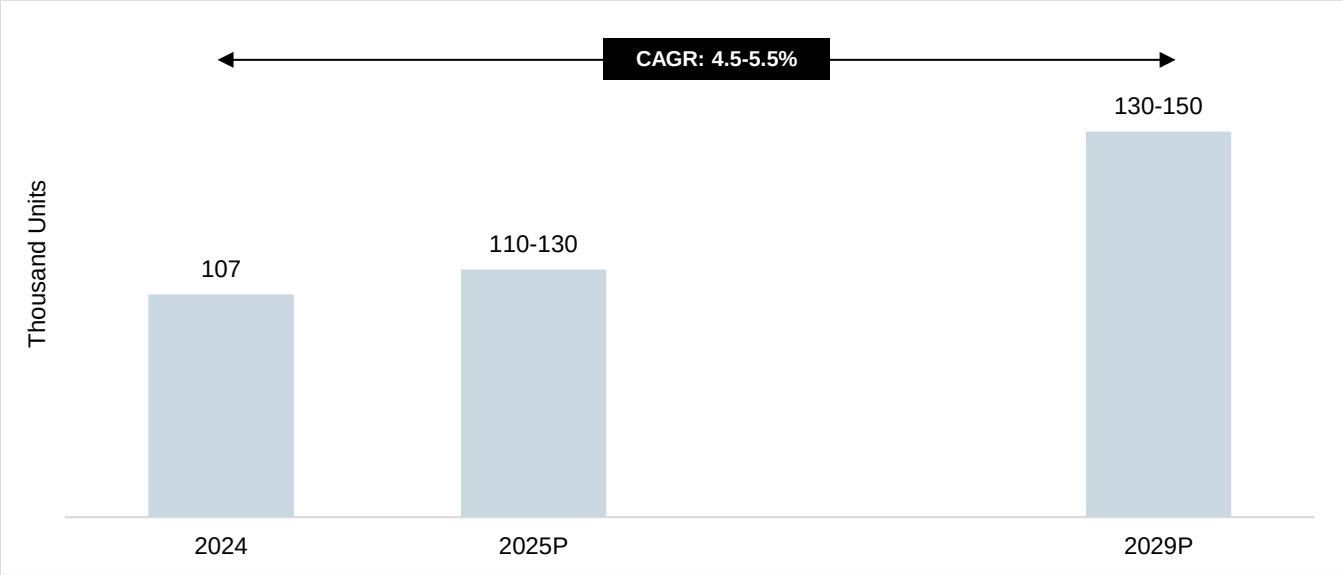
Source: Mordor Intelligence, CRISIL INTELLIGENCE

Various companies operating in the ecosystem are actively focusing on ramping up their production capacity to cater to the increasing consumer demand. We expect technological integration during the forecast period in the market, with GPS navigation systems, smartphone integration and touch screen displays.

Thus, the ATV industry is expected to grow at 4-5% CAGR between 2024 and 2029, with volumes reaching up to 350-400 thousand units.

Europe

Outlook of Europe ATV sales volumes (2024-2029)



Source: Mordor Intelligence, CRISIL INTELLIGENCE

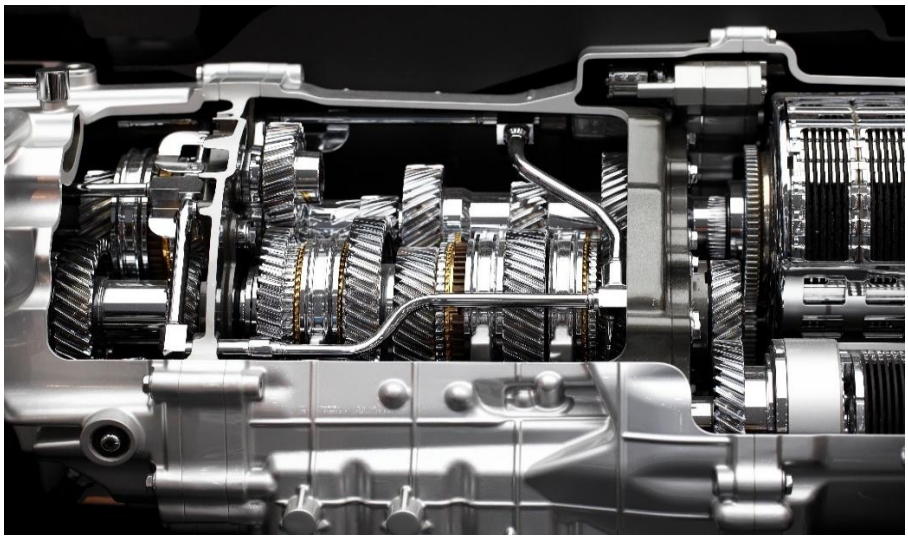
People's growing interest in sports and recreational activities has emerged as a major driving factor for ATVs. Manufacturers are working towards making frequent advancements in developing a eco-friendly versions to address growing carbon emission concerns and further boost the market size of ATVs.

Thus, CRISIL expects the ATV industry in Europe to grow at 4.5-5.5% CAGR between 2024 and 2029 with volumes reaching up to 130-150 thousand units.

7. Overview of key product segments

Overview of components for gears and transmission

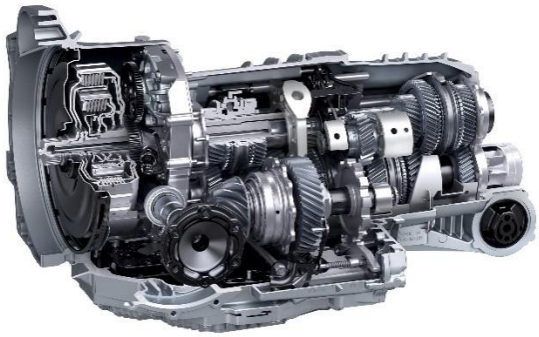
Gearbox



By meticulously adjusting speed and torque, gearboxes empower an array of machinery, from automobile engines to the drill in the toolbox. The gearbox landscape boasts of a diverse range of designs, each catering to specific applications and performance requirements. Some of the prominent gearbox types are:

Manual gearboxes

They provide a direct connection between the driver and machine. The driver, through a clutch and gear lever, manually selects the desired gear ratio, which grants precise control over the engine power and allows for manoeuvres such as engine braking. However, manual gearboxes demand a higher level of driver skill and engagement.

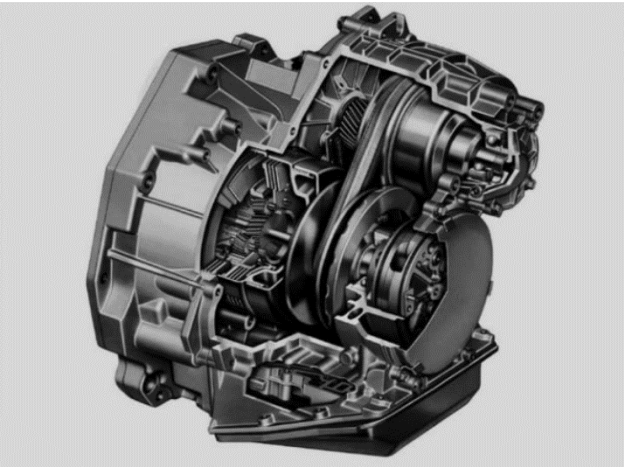


Automatic gearboxes

Offering a more convenient driving experience, automatic gearboxes liberate the driver from the task of gear selection. They utilise a complex interplay of a planetary gearset, torque converter and a sophisticated control unit, which seamlessly changes gears to optimise performance and efficiency by analysing engine speed, vehicle load and other factors.

Continuously variable transmission (CVT)

CVTs represent a distinct and innovative technology within the realm of automatic transmissions. Unlike traditional gear-based automatic transmissions, CVTs allow to seamlessly adjust gear ratios, providing a driving experience characterised by remarkable smoothness and potentially enhanced efficiency. This section delves into the intricate workings of CVTs, exploring their key components, operational principles, advantages and considerations for implementation.



Core components and functional mechanism

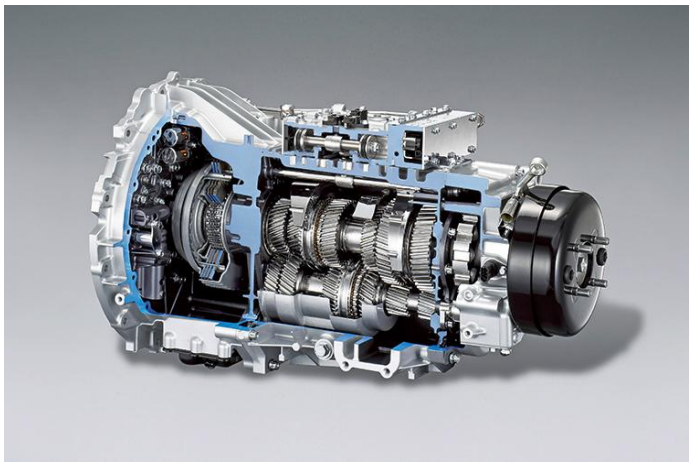
The central mechanism of a CVT lies in its ingenious pulley system, which comprises two variable-diameter cones facing each other, known as the driving and driven pulleys. The driving pulley connects directly to the engine's crankshaft, while the driven pulley transmits power to the wheels. A high-strength belt, typically constructed from steel or composite materials, connects the pulleys and transmits the engine's rotational force.

The key to a CVT's operation lies in the dynamic adjustment of these pulley diameters. An ECU acts as the conductor of this process, meticulously monitoring various parameters, such as engine speed, vehicle load and driver input. Based on this real-time data, the ECU issues precise commands to modify the diameter of the pulleys. As engine revs increase, the driving pulley expands, pushing the belt outwards. Conversely, the driven pulley contracts, ensuring optimal tension on the belt.

This continuous and dynamic manipulation of pulley diameters translates into a constantly changing gear ratio. In essence, a CVT functions as if it possesses infinitely variable gears, with the ECU selecting the most efficient ratio for any given driving situation. This stands in stark contrast to traditional automatic transmissions, which rely on a fixed set of discrete gears.

DCT

DCTs employ two clutches, each pre-selecting the next gear. This allows for lightning-fast gear changes, virtually eliminating any lag or power interruption during gear shifts. However, DCTs are no longer exclusive to high-performance cars. This innovative technology is making significant inroads into the world of two-wheelers, particularly scooters and e-bikes, offering a paradigm shift in terms of riding experience and efficiency.



Feature	DCT	CVT
Gear selection	Distinct gears pre-selected by clutches	Continuously variable ratio via pulley system
Shifting style	Rapid and precise gear changes	Seamless and uninterrupted power transfer
Efficiency	Potentially high efficiency by keeping engine/motor in optimal RPM range	Can be highly efficient at lower speeds, may lose some efficiency at higher speeds
Riding experience	Smooth with a more connected feel	Exceptionally smooth, ideal for stop-and-go traffic
Complexity	More complex design, potentially higher cost	Simpler design, potentially lower cost
Maintenance	Might require specialised maintenance or lubricants	Generally lower maintenance requirements

Major components in a gearbox

While the specific components might vary based on the gearbox type, some core elements are ubiquitous:

Gears

Gears are typically made from high-strength steel or alloys to endure the wear and tear of power transmission. They come in various sizes and the ratio between the driving and driven gear dictates the output speed and torque. The number of teeth on each gear also plays a crucial role in determining the gear ratio.

Shafts

Shaft, in its most basic form, is a long, slender, cylindrical rod designed to transmit rotational motion or torque. It is essentially a mechanical axle that serves as a bridge for power transfer between various components in machines. These rotating axles serve as the backbone of the gearbox, supporting the gears and transmitting power between them. Gearboxes may employ multiple shafts, each with its own set of gears, to achieve a wider range of gear ratios.

Bearings

Integral to the efficient operation of gearboxes are bearings, precision components that minimise friction and ensure the smooth rotation of shafts. They prevent the catastrophic consequences of direct metal-to-metal contact between rotating shafts and the gearbox housing. Bearings achieve this by providing a low-friction interface, typically employing rolling elements or a lubricating film. This significantly reduces energy losses due to friction, leading to improved efficiency, quieter operation and extended lifespan for gears and other gearbox components. Furthermore, bearings are crucial in maintaining a precise alignment between shafts and gears, which is essential for proper meshing and optimal power transmission within the gearbox. Without the mitigating effect of bearings, misalignment could lead to grinding, premature wear and even seizure of gears, ultimately compromising the functionality of the entire gearbox.

Seals

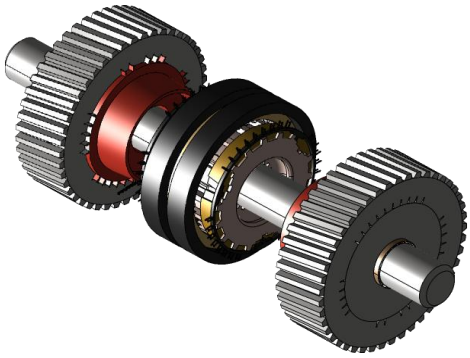
In the high-pressure world of gearboxes, seals act as guardians of lubrication. They stop precious oil from escaping, which would not only create a mess but also starve gears and bearings, leading to disaster. Seals also keep dust, dirt and moisture at bay, which can wreak havoc on gears and bearings, accelerating wear and tear. Gearboxes typically use lip, labyrinth or even double-layered cassette seals, depending on the location and pressure within the housing. Material selection is key, with nitrile rubber being common for affordability, while fluor elastomer offers superior heat resistance for tougher jobs. Seals ensure smooth operation, minimise friction and extend the lifespan of the entire gearbox.

Forks and shift mechanism

Within a manual transmission gearbox, a meticulously orchestrated interplay between forks and the shift mechanism facilitates gear changes. The shift forks, akin to a conductor's baton, serve the critical function of precisely positioning the desired gear for meshing with its partner. These typically C-shaped metal components straddle the collar or sleeve on a gear shaft, and their movement along designated grooves on the shaft achieves the necessary alignment.

The shift mechanism acts as the translator, meticulously converting the driver's input, manifested as movements of the gear lever, into precise linear motions. This linear motion, often a push or pull, is typically achieved through a shift rod within the system. The shift rod then directly connects to a specific fork, urging it along the designated shaft groove. This coordinated movement ultimately results in the gear's collar or sleeve being positioned for smooth meshing with the selected gear.

Synchromesh (manual gearboxes)



The synchromesh gearbox is a critical component within manual transmissions, particularly in automobiles. It addresses the challenge of achieving smooth engagement between gears that are rotating at different speeds during gear changes. This process, if left unaddressed, would result in significant friction and gear wears, accompanied by audible grinding noises. The synchromesh system employs friction elements to meticulously synchronise the rotational speeds of the gears before they fully engage. This synchronisation minimises the drawbacks, leading to noticeably smoother gear changes, extending the lifespan of the transmission.

Torque converter (automatic gearboxes)

The torque converter occupies a critical position within automatic transmissions, serving a dual purpose. Primarily, it functions as a fluid coupling that transmits rotational motion from the engine to the transmission. This coupling action also facilitates a crucial secondary function of torque multiplication. By strategically utilising the fluid dynamics between a rotating impeller driven by the engine and a turbine connected to the transmission, the torque converter amplifies engine torque output, particularly at lower speeds. This torque multiplication provides the additional tractive force necessary for smooth vehicle launch, especially advantageous for heavier automobiles. Furthermore, the torque converter plays a vital role during gear changes. By momentarily interrupting the direct connection between the engine and transmission, it enables gear shifts to occur smoothly, eliminating the potential for jolting sensations associated with a rigid connection. In essence, the torque converter, through its ingenious design incorporating an impeller, turbine and sometimes a stator, orchestrates a seamless transfer of power between the engine and transmission, contributing to a more refined driving experience and enhanced longevity of the automatic drivetrain.

Mass market and high performance transmission systems

Within the realm of automotive technology, transmissions play a pivotal role in regulating the transfer of power from the engine to the wheels. Some of the key differences between manual/mass market and premium/high performance transmission systems are:

Technological innovation vs established reliability

Mass market transmissions: They prioritise functionality and cost-effectiveness, often employing well-established designs and robust materials, such as steel to ensure longevity. While reliable, these designs may not incorporate the latest advancements, potentially resulting in increased weight.

High performance transmissions embrace the future with advanced technologies and materials, some of the key points of which are:

- Lightweight construction: Components meticulously crafted from high-strength aluminium alloys or even composite materials can significantly reduce the overall transmission weight, enhancing fuel efficiency, a critical aspect in today's environmentally conscious landscape
- Friction reduction strategies: Advanced bearing designs and materials meticulously engineered to minimise friction losses within the transmission. Smoother-operating gears do not just provide a pleasurable driving experience but also result in a slight augmentation in fuel economy

- ECUs (Electronic Control Unit): ECUs function as the central nervous system of the transmission, analysing driving conditions in real-time. By processing a multitude of data points, including engine speed, vehicle load and driver input, the ECU can meticulously adjust shift patterns to optimise performance and efficiency

Functionality and performance:

Mass market transmissions: They strike a balance between functionality and cost. Gear changes might not be lightning-fast and some may lack features, such as automatic rev-matching (synchronising engine speed for smoother gear changes during downshifts). While they may not be known for their speed, they consistently deliver reliable performance.

High performance transmissions: Designed to cater to those expecting superior driving experience and peak performance. The following sets them apart:

- Rapid and seamless gear shifts: Advanced clutch control systems and meticulously designed gear selection mechanisms contribute to quicker and smoother gear changes. Instantaneous and effortless gear changes offer an engaging and exhilarating driving experience
- Diverse driving modes: These transmissions might offer a plethora of driving modes (e.g. sport, comfort and eco) that meticulously alter shift patterns and engine behaviour. It offers customisable transmission that adapts to driving in comfort or sport modes
- Automatic rev-matching prowess: Some premium transmissions are equipped with the ability to automatically adjust the engine speed to synchronise with the selected gear during downshifts. This eliminates the need for the driver to perform heel-toe manoeuvres (a specialised technique for matching revs), resulting in smoother downshifts, especially for performance driving

Cost considerations

Mass market transmissions: They are generally less expensive to purchase and maintain due to their simpler designs and readily available components. They offer a solid value proposition for those who prioritise affordability and a straightforward driving experience.

High performance transmissions: They come at a premium price. The advanced technologies and materials employed in their construction translate into a higher initial investment. The cost of maintenance might also be slightly higher due to the potentially more intricate systems involved.

Overview of components for bike powertrain

Transmission system for bikes and e-bikes

Derailleur systems

Derailleur systems reign supreme as the most ubiquitous transmission system for bicycles, both traditional and e-bikes. Their ability to offer an array of gears makes them perfect for conquering diverse terrains, catering to amateurs and professional cyclists alike.

Considerations for derailleurs:

- Maintenance needs: Regular care is crucial for optimal performance. Tasks, such as cable adjustments, derailleur alignment and chain lubrication need a regular check.
- Vulnerability factor: Exposed derailleurs are susceptible to damage from rocks or crashes on rough terrains
- Shifting efficiency: Derailleur systems might experience some efficiency loss under high torque situations, which can be a factor for powerful e-bikes

Shift in trend to alternative options

The transmission system in e-bikes has evolved. Early models employed rudimentary friction drives, later replaced by the adoption of traditional derailleur systems from bicycles. While derailleurs offered wider gear ranges, the additional stress from electric motors presented challenges. Consequently, contemporary trends favour two distinct alternatives: Internal gear hubs (IGH) and CVT.

Internal gear hubs

IGHs constitute a distinct transmission technology employed within bicycles and e-bikes. Unlike traditional derailleur systems that feature exposed components, IGHs are encapsulated units situated within the rear hub of the vehicle. This design offers numerous advantages, including low maintenance requirements and dependable gear shifting, making them a compelling alternative for riders prioritising these aspects. Among the numerous players, few prominent manufacturers namely, Shimano and Rohloff have established themselves in the internal gear hubs market for bicycles.

At the core of an IGH lies a planetary gearset. This ingenious mechanism incorporates multiple gears arranged in a configuration reminiscent of planets orbiting a central sun gear. By meticulously manipulating the engagement of these gears, the IGH achieves a spectrum of gear ratios, thereby enabling the rider to adapt to varying terrain demands.

Considerations for IGH:

Weight: IGHs weigh more than derailleur systems, potentially posing a concern for riders who prioritise a lightweight bicycle.

Limited gear range: While offering a sufficient range of gears for many riders, IGHs typically provide fewer gear options, compared with derailleurs. This limitation might render them less suitable for conquering exceptionally challenging terrains that demand a wider gear range for optimal performance.

Maintenance complexity: Although requiring less frequent maintenance, some IGHs might necessitate specialised servicing by a qualified mechanic, unlike basic derailleur adjustments that can often be performed by the rider.

CVT

CVTs are emerging as a disruptive technology within the e-bike domain. Unlike the traditional derailleur systems that offer discrete gear ratios, CVTs provide a seamless spectrum of gear ratios, fundamentally altering the riding experience. Enviolo is the first to introduce commercially available CVT technology for bicycles in 2007 and has patented their technology. This analysis dissects the key advantages and considerations associated with CVTs in e-bikes. Powertrains are integrated systems designed to propel a vehicle by converting energy into motion. They include the engine or motor, energy storage systems, the transmission, driveshaft, and other related components that work together to deliver power to the vehicle's wheels.

Advantages of CVTs in e-bikes:

Unparalleled smoothness: CVTs eliminate the jolts associated with gear changes in derailleur systems, resulting in an exceptionally smooth riding experience. This is particularly noticeable during acceleration and hill climbing, translating to enhanced comfort and a more natural feel for the rider.

Effortless gear adjustment: Many CVTs incorporate automatic or semi-automatic functionalities that dynamically adjust the gear ratio based on factors, such as pedal cadence and terrain. This eliminates the need for manual gear changes, allowing riders to focus solely on the act of cycling.

Potential efficiency gains: By maintaining the electric motor within its optimal RPM range, CVTs have the potential to improve efficiency. This translates to a potentially maximised battery range, a crucial factor for e-bikes.

Reduced maintenance requirements: Due to a minimised number of moving parts, compared with derailleurs, CVTs eliminate abrupt gear shifts and promote consistent pedalling cadence, resulting in improved efficiency and reduced wear and tear over time.

Considerations for CVTs in e-bikes:

Cost factor: CVTs typically command a higher price point, compared with other alternative options.

Weight: While lighter than some internal gear hubs, CVTs can contribute to a slight weight increase in e-bikes, compared with derailleurs.

Electric drive unit (EDU)

The EDU is an integrated system with motor, battery and controller as key components and has a major impact on the overall performance and functionalities of end-applications, such as e-bikes or electric two-wheelers. This intricate system integrates several key components that function synergistically to propel the rider forward.

Electric motor: This is an essential component of the EDU, transforming electrical energy garnered from the battery into mechanical energy that drives the wheels. Brushless DC (BLDC) motors are vital in e-bikes, owing to their superior efficiency, reliability and quiet operation. The brushless design minimises friction and wear, contributing to an extended lifespan. BLDC motors function on the principle of magnetic interaction. Permanent magnets fixed to the rotor (the rotating component) interact with electromagnets (coils) on the stator (the stationary component). By electronically regulating the current flow within these coils, a rotating magnetic field is established. This magnetic field exerts a pulling force on the rotor, causing it to spin and propel the e-bike forward.

Battery: Functioning like the fuel tank of a conventional vehicle, the battery safeguards the electrical energy that energises the motor. Lithium-ion batteries are the predominant choice due to their exceptional energy density and extended lifespan. Battery capacity, quantified in watt-hours (Wh), determines the potential range achievable on a single charge. Consequently, a higher Wh rating translates to a greater travel distance.

Controller: This intelligent unit serves as the central nervous system of the EDU, meticulously regulating the flow of electricity from the battery to the motor. It receives signals transmitted by various sensors, including the pedal assist sensor or throttle and calibrates the motor's power output based on these inputs. The controller acts as an orchestra conductor, ensuring all components function in harmonious unison.

Pedal assist sensor: It plays a crucial role in initiating motor assistance. It meticulously detects the rider's pedalling motion. Upon commencement of pedalling, the sensor transmits a signal to the controller, instructing the motor to engage and provide supplementary power to augment the rider's effort. Certain e-bikes incorporate a throttle mode, enabling purely electric operation that eliminates the need for pedalling altogether.

Electric drive motor

E-bikes are becoming increasingly popular due to their ability to provide an environment-friendly and assisted ride. A key component of an e-bike is the electric drive motor, which provides the extra boost to propel the bike forward. The two main types of electric drive motors used in e-bikes are hub and mid-drive motors. Each type offers distinct advantages and disadvantages, making the choice dependent on riding style and needs.

Hub motors

Hub motors are a widely employed type of motor integrated within the wheel hub of an e-bike.

Advantages of hub motors:

Hub motors are significantly favoured by e-bike riders, owing to several compelling attributes:

- Their straightforward design facilitates integration into existing bicycles, making them a popular choice for converting conventional bicycles into e-bikes
- Compared with their mid-drive counterparts, hub motors possess a simpler design with fewer moving parts. This minimises downtime, in turn reducing maintenance, keeping riders focused on the road
- They are more affordable than mid-drive motors. This economic advantage makes them an attractive option for budget-conscious riders seeking an e-bike experience

Considerations for selection of hub motors:

While hub motors offer numerous advantages, there are aspects that warrant careful consideration:

Weight distribution: The concentrated weight within the wheel can influence the handling characteristics of an e-bike, particularly for lighter models.

Hill climbing performance: While geared hub motors provide some assistance on inclines, they might not be the optimal choice for tackling extremely steep hills.

Sensor technology: Hub motors frequently utilise cadence sensors, which get activated based on the pedalling speed. This can result in a less natural riding experience, compared with torque sensors found in some mid-drive motors. Torque sensors respond to the force applied by the rider, offering a more intuitive feel.

Mid-drive motors

Mid-drive motors offer a unique and powerful e-bike riding experience, compared with their hub motor counterparts. Nestled within the frame, these motors work in concert with the e-bike's drivetrain, unlocking a world of possibilities for riders seeking performance and a natural riding feel.

Unlike hub motors, which reside directly in the wheel hub, mid-drive motors occupy a central location near the pedals. This strategic positioning offers several advantages:

- Mid-drive motors connect directly to the bike's drivetrain, integrating seamlessly with the existing gears
- This intimate connection with the drivetrain allows mid-drive motors to leverage the bike's existing gears leading to optimal power distribution on flat terrains and exceptional climbing ability on inclines
- Mid-drive motors typically have a higher power output, compared with hub motors
- Mid-drive motors result in better weight distribution as compared to hub motors that results in a comfortable feeling for riders

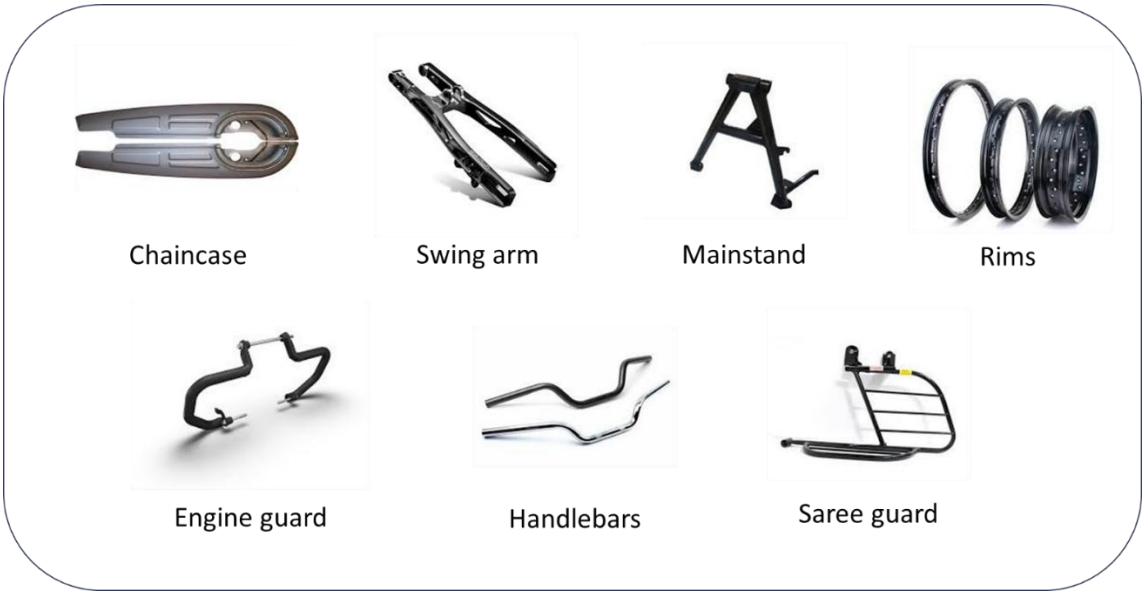
Considerations for selection of mid-drive motors:

Maintenance: The complex design of mid-drive motors, with their intricate gear interactions, might necessitate more frequent servicing, compared with hub motors.

Cost considerations: The intricate design and functionality of mid-drive systems make them more expensive than their hub motor counterparts.

Installation nuances: Integrating a mid-drive motor often requires professional assistance, especially for complex conversions. While some skilled riders might attempt do-it-yourself installations, professional help ensures proper integration and optimal performance.

Overview of components for alloys and metallics



Chaincase

Chaincase, also known as a chainguard, fulfils a critical function in ensuring the continued efficacy of the drivetrain and safeguarding the rider. Following are some of the features of a chaincase:

Preservation of the chain assembly: A primary function of the chaincase lies in its encapsulation of the chain and sprocket assemblies. This enclosure shields the chain from the negative impact of dirt debris, and moisture. By mitigating such exposure, the chaincase extends the operational lifespan of the chain and minimises the need for frequent cleaning and lubrication.

Enhanced rider safety: The chaincase serves as a vital safety element by preventing inadvertent contact between the moving chain and the rider's extremities or loose articles of clothing. This safeguard is particularly important for new cyclists or children, who may be unfamiliar with the potential hazards of an exposed chain.

Protection of attire: The chaincase acts as a barrier, preventing the chain from coming into contact with the rider's clothing. This not only prevents unsightly and potentially persistent grease stains but also eliminates the possibility of snagged clothing, thereby contributing to a more comfortable and aesthetically pleasing cycling experience.

Swing arm

A swingarm is a key component of a motorcycle's suspension system. It is a single or double-sided mechanical device that:

- **Attaches the rear wheel of a motorcycle to its body:** The swingarm pivots at its front attachment point, allowing the rear wheel to move up and down as the motorcycle travels over bumps and uneven terrain
- **Holds the rear axle:** The rear axle of the motorcycle is secured within the swingarm, allowing the wheel to rotate freely
- **Acts as a mounting point for the rear suspension:** The shock absorber(s) and linkage system of the rear suspension are typically connected to the swingarm. This allows the suspension to compress and rebound, absorbing impacts, and providing a smoother ride

Mainstand

A mainstand, also sometimes called a centerstand, is a kickstand located in the centre of a bicycle or motorcycle providing upright support for the entire vehicle. When deployed, the mainstand lifts the rear wheel of the bicycle or motorcycle off the ground, keeping the entire vehicle upright and stable. Following are some of the featured of a mainstand:

- **Parking and maintenance:** The mainstand allows for secure parking on uneven surfaces or soft ground where a side stand may sink in. It is also crucial for maintenance tasks such as cleaning the drivetrain, repairing punctures or adjusting brakes since both wheels are accessible when the bike is upright
- **Loading and unloading:** The mainstand facilitates easier loading and unloading of cargo or passengers, especially on heavier motorcycles where a side stand may cause problems
- **Security:** Some mainstands incorporate locking mechanisms to prevent the bike from being easily rolled away, offering an additional layer of security

Rims

The rim plays a critical role in keeping the wheels of a motorcycle or bicycle rolling smoothly.

Role of rims:

- Shaping the ride: Rims provide the defined shape for the tyre. This not only allows the tyre to maintain its inflated form but also influences its overall performance. A wider rim can offer better grip and stability for certain riding styles, while a narrower one might prioritise aerodynamics.
- Spoke sanctuary: The tiny holes drilled into the rim serve as the anchor points for the spokes, which are the thin metal rods that connect the rim to the hub at the centre of the wheel. The interaction between the spokes and the rim creates a tensioned structure, transferring the pedalling power from the hub all the way to the ground, propelling forward movement.

Engine guard

An engine guard, also sometimes called a crash bar or bull bar, is a metal frame or bar attached to a motorcycle or scooter specifically designed to protect the engine and other critical components in the event of a crash or fall.

Key functions and benefits of engine guards:

- Protection in case of a fall: The primary function of an engine guard is to absorb impact and deflect blows away from the engine block, oil filter, exhaust pipes and other vulnerable parts of the motorcycle. This can help minimise damage and prevent costly repairs in case of a fall
- Reduced damage during low-speed tip-overs: Engine guards can also offer some protection during low-speed tip overs, preventing the engine from directly contacting the ground and potentially cracking the crankcase or other components
- Improved off-road capability: For off-road enthusiasts, engine guards provide additional protection against rocks, debris and other hazards encountered on rough terrains
- Aesthetics and style: Some engine guards can enhance the visual appeal of a motorcycle, giving it a rugged and aggressive look

Handlebars

Handlebars are a crucial component for bicycles and motorcycles that help the rider steer and control the direction of the vehicle. Typically made from lightweight and strong materials, such as steel, aluminium or carbon fibre, they connect to the stem (bicycles) or the upper yoke (motorcycles) of the frame. There are different handlebar styles for bicycles and motorcycles:

Bicycles:

- Drop bars: Preferred by cyclists for their curved design that allows for a more aerodynamic, tucked-in position, these bars offer multiple hand positions for comfort and control during extended rides
- Flat bars: These straight handlebars provide an upright riding posture, making them popular for comfort bikes, hybrids and mountain bikes, offering good control and maneuverability
- Bullhorn bars: They are similar to drop bars but have shorter drops, commonly used on time trial and triathlon bikes for optimal aerodynamics
- Butterfly bars: These wide, flared handlebars offer a comfortable upright position, often seen on comfort and touring bikes, providing leverage for steering and stability
- Mountain bike handlebars: Wider and risen more than flat bars, they provide increased control and leverage for navigating rough terrain

Motorcycles:

- Standard handlebars: These straight or slightly angled bars offer an upright riding position, common on standard motorcycles and cruisers
- Beach bars: They are similar to standard handlebars but with a more relaxed backward sweep, promoting a laid-back riding posture often seen on cruisers
- Clip-on handlebars: These comprise two separate bars clamped onto the fork tubes, allowing for a tucked-in, aerodynamic position favoured by sportbike riders
- Ape hangers: They are tall handlebars, offering a unique look and more leverage for low-speed riding, but potentially affecting handling at higher speeds

Materials:

- Handlebars are typically constructed from lightweight and strong materials such as:
- Aluminium: The most common material, offering a good balance of weight, strength and affordability
- Carbon fibre: Lighter than aluminium but more expensive, it offers a high-performance option for weight-conscious riders
- Steel: Strong and durable, but heavier than others. It is less common nowadays due to weight concerns

Saree guard

The primary function of a saree guard is to safeguard loose-flowing and long clothing while riding a motorcycle or scooter. It acts as a physical barrier, preventing the rider's garment from getting entangled in the wheels or chain. This not only protects the garment from potential tears, snags or grease stains but also addresses a crucial safety concern.

Major technologies used in the manufacturing processes of alloys and metallics

The type of manufacturing technology mainly depends on the desired properties (weight, strength and cost), production volume and design complexity of the component. Technologies used for some key parts, along with separate considerations for each:

Chaincase, main stand, swingarm (bikes with motors)

Manufacturing technologies:

- Sheet metal stamping: This is a common and cost-effective method. Sheet metal is punched and formed into the desired shapes using dies and presses and is often used for chaincases and main stands, owing to its speed and affordability
- Metal injection moulding: This technique is suitable for creating complex shapes. Metal powder is mixed with a binder, moulded into shape and then heated to remove the binder and fuse the metal particles. This can be used for some chaincases and swingarms on motorbikes

Considerations:

Material selection (steel or aluminium) significantly impacts the final product's weight, strength and cost.

Rims

Manufacturing technologies:

- Extruded aluminium: The most widely used method, aluminium billets are heated and forced through a die to create a long continuous profile, which is then cut and welded to form the rim

- Carbon fibre layup: This method is used for lightweight, high-performance rims. Carbon fibre sheets are layered in a specific orientation and bonded together with resin. This requires a specialised mold and curing process

Considerations:

The choice of material (aluminium or carbon fibre) has a major influence on the rim's weight, strength and overall cost.

Engine guard (motorcycles)

Manufacturing technologies:

- Tube bending: This is a common technique, also used for handlebars. Metal tubes are heated and bent using mandrels or dies to form the desired shape. This is used for engine guards on motorcycles as it offers good strength and allows for customisation
- Computer numerically controlled (CNC) machining: This method is used for complex shapes or high-precision components. CNC machines precisely remove material from a solid block of metal to create the desired form. This can be used for some engine guards with intricate designs

Considerations:

Material selection (typically steel) and design complexity are key factors affecting the manufacturing process chosen for engine guards.

Handlebars

Manufacturing technologies:

- Tube bending: This is the most common method for metal handlebars. Metal tubes are heated and bent using mandrels or dies to form the desired shape
- Forging: This method is used for high-strength handlebars, such as those on some mountain bikes. Metal is heated and hammered into shape using dies

Considerations:

Material selection (steel or aluminium) is important, along with the handlebar type (flat, drop or other styles).

Saree guard

Manufacturing technologies:

- Sheet metal stamping (as mentioned above): This is a common choice for saree guards, especially those that are fixed, owing to its affordability and ability to create simple shapes
- Metal bending: This can be used for curved sections of a saree guard, especially for those that are fixed, which wrap around the frame
- Welding: This is used to join different metal components of a saree guard, especially for those fixed

Considerations:

Material selection (steel or aluminium) is a factor, along with determining if the saree guard is fixed or detachable.

Impact of electrification on all components (combined for gears and transmission, bike powertrain and alloys & metallics)

The EV revolution is causing a ripple effect throughout the automotive industry and the component manufacturing sector is no exception. While the demand for traditional engine and drivetrain components, such as engine gears, chaincases and carburettors will plummet, several other component categories will see a significant shift. Essential components, such as handlebars, safety features and frames will be crucial for EVs, albeit potentially with some design modifications. Suspensions, wheels and instrument clusters might require adjustments to accommodate the unique characteristics of EVs.

The mobility industry is experiencing a transformative shift across the globe due to the increasing electrification of vehicles, significantly impacting powertrain solutions such as motors, gearbox/transmission systems, and integrated e-drive units.

Adoption of electric vehicles (EVs) necessitates a paradigm shift in the design and function of gears and transmission components. The multi-speed gearboxes associated with internal combustion engines are likely to be supplanted by simpler designs in EVs. This includes single-speed reduction gears, optimized for efficiently matching the high RPM of electric motors to the optimal operating speed of the wheels. Alternatively, limited-speed gearboxes with a focus on a select range of well-spaced ratios might be employed in high-performance EVs or those designed for substantial towing capacity. This evolution towards a more streamlined transmission translates to a lighter overall weight, potentially contributing to improved vehicle range and efficiency. However, the emphasis on simplicity does not diminish the critical role of high-quality gears. Electric motors generate significant torque from a standstill, placing immense stress on transmission components. Consequently, the continued focus on robust materials and precision manufacturing remains paramount to ensure reliable operation.

Furthermore, the regenerative braking systems prevalent in EVs introduce the challenge of bi-directional power flow through the transmission. This necessitates gears with exceptional wear resistance and durability to handle this reversed power flow without compromising performance or longevity. In essence, the electrification of the automotive industry compels a shift towards high-quality, efficient transmissions specifically designed to address the unique demands of electric motors.

However, the most exciting opportunities lie in the development and production of entirely new component categories. Electric motors, inverters, battery management systems and power electronics will be important for EVs and their demand is poised to surge. Additionally, the rise of EVs necessitates the creation of new charging infrastructure components, such as stations, connectors and related hardware. This transition presents a significant challenge, but also a golden opportunity for component manufacturers who can adapt to and innovate new technologies. By catering to the evolving needs of the electric mobility revolution, the industry can ensure a smooth shift towards a cleaner and more sustainable future.

8. Overview of forging in auto-components

Forging is one of the oldest and most essential metalworking processes, where metal is shaped using compressive forces, typically applied through hammers, presses, or rolling machines. This process enhances the mechanical properties of the metal by refining its grain structure, increasing its strength, toughness, and resistance to fatigue. The forging industry plays a critical role in manufacturing, supporting sectors such as automotive, aerospace, industrial machinery, power generation, construction, railways, and mining equipment. Forged components are preferred in applications that require high strength, durability, and reliability under extreme operating conditions.

The automotive industry is the largest consumer of forged components due to the high-performance requirements of vehicles. Forging ensures that automotive parts can withstand mechanical stress, high temperatures, and prolonged use without failure. Engine components such as crankshafts, connecting rods, camshafts, and pistons are commonly forged to enhance durability and resist wear. Transmission parts, including gears, shafts, and yokes, benefit from forging to maintain strength under continuous load cycles. Chassis and suspension components like control arms, steering knuckles, and wheel hubs are also forged to provide structural integrity and impact resistance. Additionally, drivetrain components such as axles, differential gears, and drive shafts are forged to handle torsional and bending stress efficiently.

Materials used in forging vary depending on application requirements, with steel and aluminium being the most common. Steel forgings offer high tensile strength, toughness, and impact resistance, making them suitable for critical load-bearing components. Aluminium forging is increasingly adopted in the automotive industry due to its lightweight properties, which contribute to improved fuel efficiency and lower emissions. Titanium and nickel alloys are used in specialized applications requiring high temperature and corrosion resistance, such as aerospace and high-performance automotive components.

Forging is categorized based on the type of equipment and press capacity used, which influences the size and complexity of components that can be manufactured. Small-scale forging operations typically use hammers and presses with capacities ranging from 250 to 2,500 tons, suitable for precision automotive and industrial components. Medium-sized forges utilize press capacities between 2,500 and 10,000 tons, enabling the production of larger and more complex parts like crankshafts and axles. Heavy-duty forging presses exceed 10,000 tons and are used for manufacturing large structural components for aerospace, power generation, and heavy machinery. These high-tonnage presses allow the production of massive components with precise grain flow alignment, ensuring superior mechanical properties.

Forged components provide significant advantages over other manufacturing methods such as casting. The forging process aligns the metal's grain structure along the contours of the component, enhancing strength and fatigue resistance. This results in parts that are stronger and more reliable than cast or machined equivalents. Forged components also exhibit improved impact resistance, making them ideal for safety-critical applications such as automotive suspension and aerospace landing gear. The process enables the production of near-net-shape parts, reducing material waste and machining time, leading to cost-effective manufacturing. Additionally, forging allows for superior metallurgical consistency, ensuring predictable performance under extreme conditions.

Globally, the forging industry is driven by major players that have established expertise in advanced forging techniques, material science, and automation. Some of the leading global forging companies include Thyssenkrupp (Germany), Bharat Forge (India), Nippon Steel Corporation (Japan), Aichi Steel (Japan), and American Axle &

Manufacturing (USA). These companies supply forged components to automotive OEMs, aerospace manufacturers, and heavy industries, maintaining stringent quality standards and technological advancements. In India, Bharat Forge is a dominant player known for its high-precision forging capabilities and extensive product portfolio, catering to automotive, railways, defence, and industrial applications. Other prominent Indian forging companies include Ramkrishna Forgings, MM Forgings, and Amtek Auto, all of which contribute significantly to the global supply chain.

Technological advancements in the forging industry continue to drive efficiency, precision, and sustainability. Automation and robotics are increasingly integrated into forging operations to improve productivity and consistency while reducing manual labour. Advanced simulation techniques and AI-driven process optimization are being employed to enhance material utilization and reduce defects. Additionally, the adoption of green forging practices, including energy-efficient heating methods and sustainable material sourcing, is gaining traction to minimize the environmental impact of forging operations.

The demand for forged components is expected to grow in alignment with advancements in automotive and industrial applications. The shift towards electric vehicles (EVs) presents new opportunities for forging in battery casings, lightweight structural components, and electric drivetrain systems. Similarly, the aerospace and power generation industries continue to rely on forging for critical components requiring superior mechanical performance. With ongoing innovations in materials, process automation, and energy-efficient forging techniques, the industry is poised to maintain its relevance as a backbone of global manufacturing.

9. Gearbox and Transmission Design Consultancy Services

Gearbox and transmission design consultancy services offer specialized expertise in developing components tailored to the precise needs of industries such as automotive, aerospace, industrial machinery among few others. These services cover the entire design lifecycle, from initial concept development and detailed engineering to final design validation, ensuring components meet stringent performance, reliability, and durability standards. With a strong emphasis on innovation and efficiency, these consultancies ensure that designs adhere to industry-specific regulations and operational requirements while delivering solutions that are both robust and cost-effective.

In addition to component design, consultancy services play a critical role in facilitating the transition to manufacturing. This includes optimizing designs for production, advising on material selection, and ensuring components are manufacturable without compromising on quality or cost efficiency. By bridging the gap between design and production, these services help businesses streamline their development processes.

Companies, particularly OEMs, rely on gearbox and transmission design consultancy services to access advanced expertise that enhances both design precision and manufacturing efficiency. By leveraging these services, businesses can optimize component performance, ensure seamless production integration, and maintain compliance with stringent industry standards.

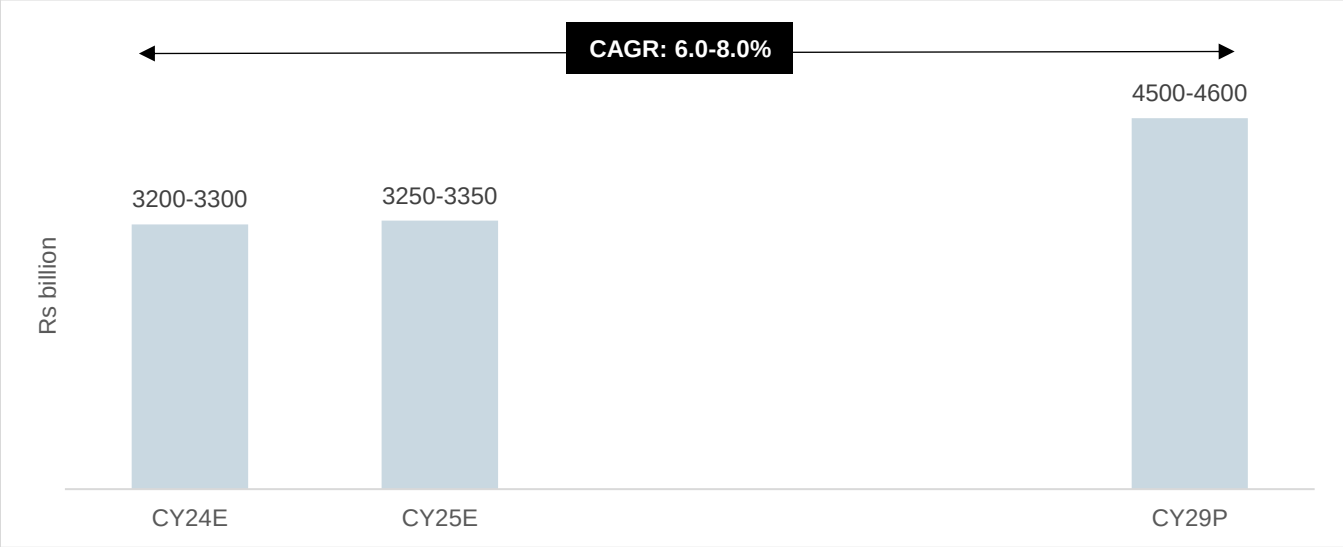
Currently, these services are primarily utilized for high-end automotive vehicles, where precision engineering and advanced performance requirements drive the need for specialized expertise. While gearbox and transmission design consultancy remain a niche segment, its significance in the coming years is expected to grow as the demand for vehicles with enhanced performance, reliability, and durability continues to rise. The increasing focus on technological advancements in mobility solutions will further drive the need for specialized engineering expertise in this field.

Companies such as ZF Friedrichshafen AG, Ricardo PLC, Hewland Engineering Ltd, Colotti Trasmissioni, AVL List GmbH, Drive System Design (UK), FEV are amongst the prominent players of this industry, offering expertise in designing, developing, and optimizing transmission systems to meet stringent performance and reliability standards. These firms play a crucial role in enhancing powertrain efficiency, ensuring seamless integration with manufacturing processes, and driving technological advancements in mobility solutions.

10. Market sizing and outlook of components

Gears & transmissions

Market sizing for gears & tranmissions components (CY24E–CY29P)



Note: 1. Above figures comprise of values for gear components (global) and gear-box assembly (domestic & global)

2. Gear components compromise of values for India, United States, EU, and ASEAN and vehicle segments included for market sizing are motorcycles, passenger cars, e-3W and ATV

3. Gear components segment covers - Engine Gear and Transmission gear, shafts, and gear-set assemblies

4. Gear-box assembly (domestic) compromise of values for India and vehicle segments included for market sizing are cars and e-3W

5. Gear-box assembly (global) comprise of values for United States, EU, and ASEAN and vehicle segments included for market sizing are motorcycles (>600 cc) and ATV

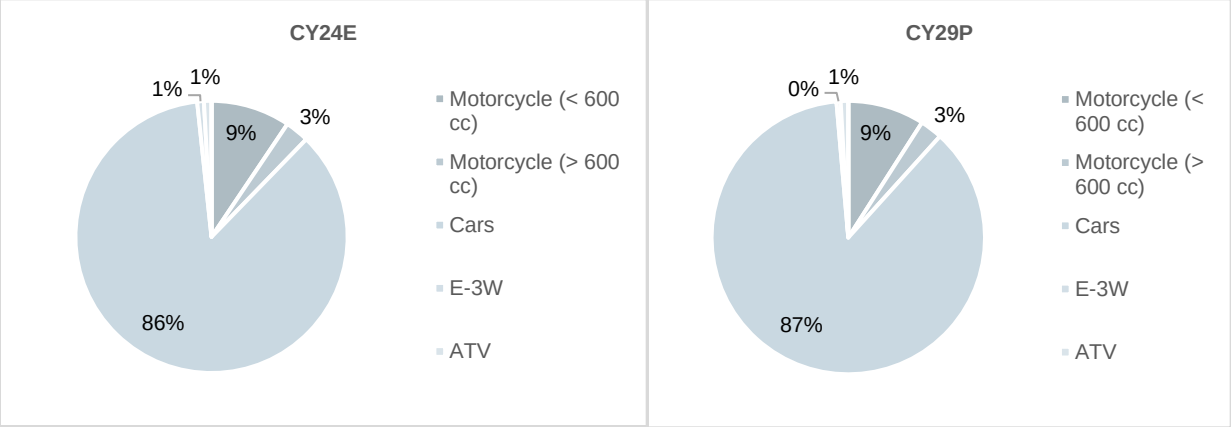
Source: Mordor Intelligence, CRISIL INTELLIGENCE

The size of the market for gears & transmissions is estimated to clock a CAGR of 6.0-8.0% between calendar years 2024 and 2029. In calendar 2024, the estimated market size is anticipated to be in the range of Rs 3,200-3,300 billion, whereas in calendar 2025, it is expected to marginally increase 0-2% to Rs 3,250-3,350 billion.

For the two wheeler segment, gears & transmissions is estimated to clock a CAGR of 4-6% between calendar years 2024 and 2025. In calendar 2024, the estimated market size is anticipated to be in the range of Rs 394-404 billion, and the market size is expected to expand to Rs 524-544 billion by 2029.

On the other hand for the passenger vehicle segment, gears & transmissions is estimated to clock a CAGR of 6-8% between calendar years 2024 and 2029. In calendar 2024, the estimated market size is anticipated to be in the range of Rs 2,700-2,900 billion, and the market size is expected to expand to Rs 3,860-4,060 billion by 2029.

Share of vehicle categories for market sizing of gears & tranmissions



Source: Mordor Intelligence, CRISIL INTELLIGENCE

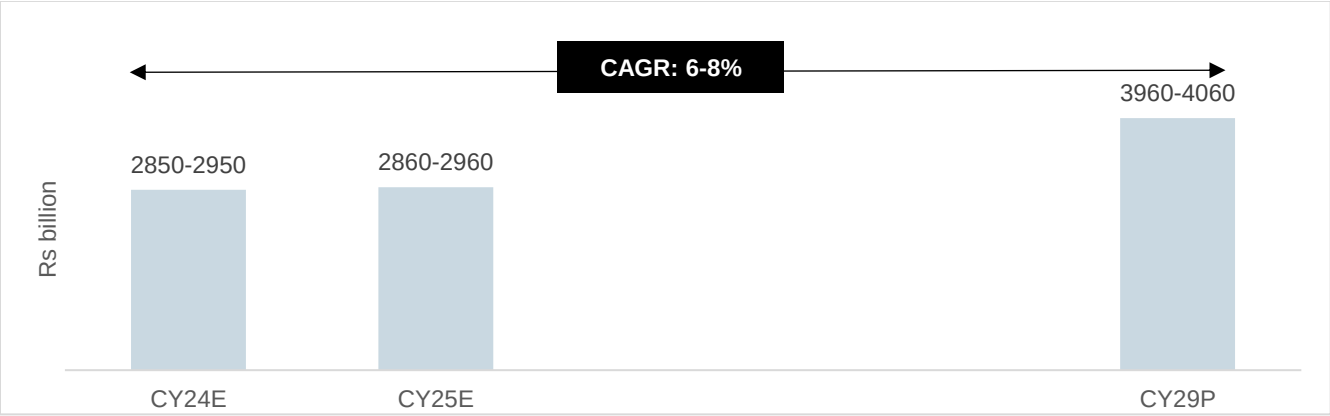
Within the highly competitive market, few key players such as ZF Friedrichshafen AG, Musashi Co. Ltd., BorgWarner Inc. and GKN PLC stand out and are recognized for their advanced technologies, innovative solutions and strong market presence.

Electric vehicles might restrict demand for traditional engine gears in certain vehicle segments, new opportunities shall emerge for EV-specific components. Electric Vehicles (EVs) require an integrated transmission system to optimize their performance, efficiency, and driving experience. Unlike traditional multi-gear systems, these advanced single or multi-speed gearboxes enhance acceleration, energy efficiency, and overall vehicle functionality. While providing these features, EVs also require high efficiency for improved range and have strict noise, vibration, and harshness (NVH). Therefore, while electric motors are silent, electric transmission must meet these NVH requirements.

Detailed assessment of the gear component market and gear-box assembly market is provided below.

Gear components

Market sizing for gear components (CY24E-CY29P)



Note: 1. Above figures comprise of values for India, United States, EU, and ASEAN

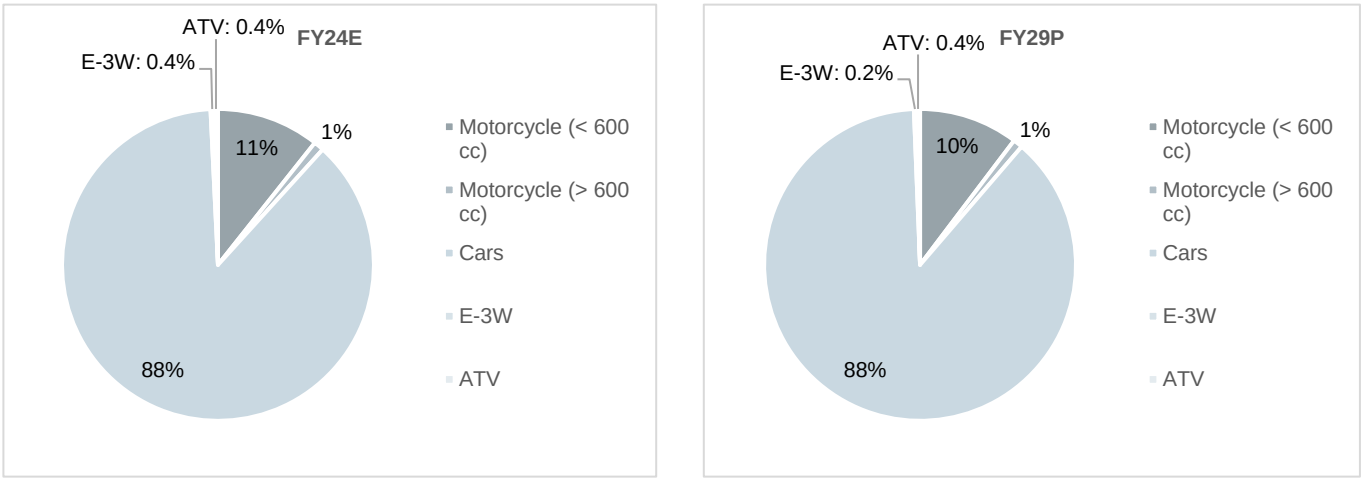
2. Vehicle segments included for market sizing of gear components are motorcycles, passenger cars, three-wheelers and ATV

3. Gear components segment covers - Engine Gear and Transmission gear, shafts, and gear-set assemblies

Source: Mordor Intelligence, CRISIL INTELLIGENCE

The size of the market for gear components is estimated to clock a CAGR of 6-8% between calendar years 2024 and 2029. In calendar 2024, the estimated market size is anticipated to be in the range of Rs 2,850-2,950 billion, whereas in calendar 2025, it is expected to marginally increase 0-2% to Rs 2,860-2,960 billion. Global markets are going to drive the gear components market in the next five years, with an ~80-85% share by 2029, leaving India with the remaining share of ~15-20%, or Rs 3,960-4,060 billion in calendar 2029.

Share of vehicle categories for market sizing of gear components



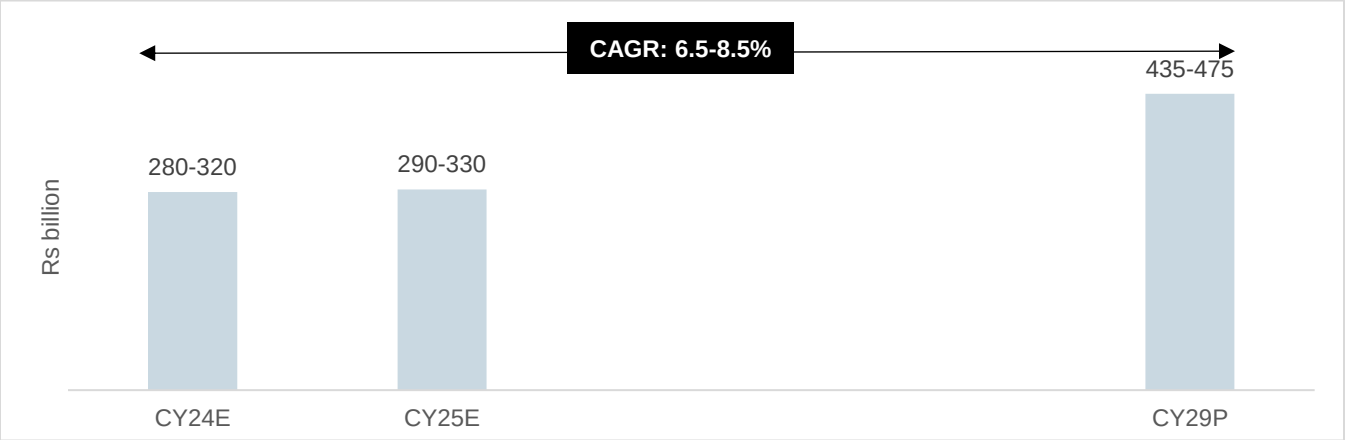
Source: Mordor Intelligence, CRISIL INTELLIGENCE

Within the motorcycle segment, greater than 600 cc motorcycles are ICE-driven, which require the integration of efficient gear components, thereby contributing to the growth of gear components market. Consumers from Europe and North America will form a major customer base for motorcycles with more than 600 cc, due to the growing disposable income. Moreover, the penetration of e-motorcycles is significantly lower, with major manufacturers still in the research and development phase.

While EVs might restrict some demand for traditional engine gears in certain vehicle segments, new opportunities shall emerge for EV-specific components, such as electric motor gears that will continue to drive the overall gear components market.

Gear-box assembly

Market size of for gear-box assembly - India (CY24E – CY29P)



Note: 1. Above figures comprise values for India

2. Vehicle segments included for market sizing of gear-box assembly are cars and e-3W

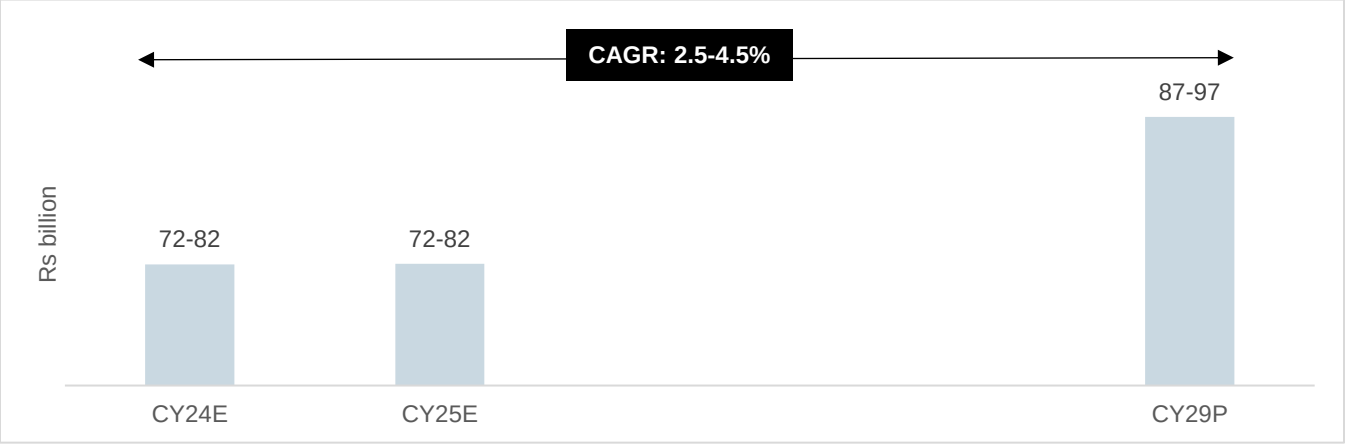
Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market size of gear-box assembly for Indian markets is estimated to clock a CAGR of 6.5-8.5% during calendars 2024 to 2029. In calendar 2024E, the estimated market size is anticipated to be in the range of Rs 280-320 billion, whereas in calendar 2025E, it is expected to increase a marginal 0-2% on-year. Cars are going to dominate the overall market value with over ~90% share. The market value in calendar 2029P is expected to reach Rs 435-475 billion.

The passenger vehicle industry is expected to grow at a 4.5-6.5% CAGR between fiscals 2024 and 2029, majorly driven by compact and mid-size SUVs (7-10% CAGR during the same period).

On the other hand, the Indian three-wheelers industry (ICE) is expected to witness a de-growth of 3-5% CAGR between fiscals 2024 and 2029. Growth will likely be outweighed by the broader shift towards electrification.

Market sizing for gear-box assembly – global (CY24E – CY29P)



Note: 1. Above figures comprise of values for United States, EU, and ASEAN

2. Vehicle segments included for market sizing of gear-box assembly are motorcycles (>600 cc) and ATV

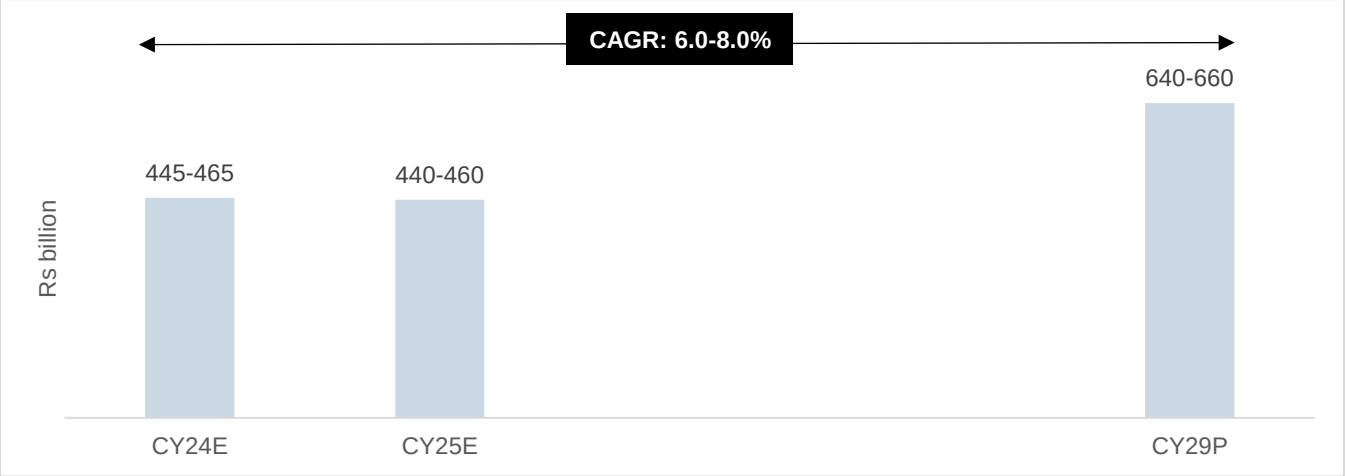
Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market size of gear-box assembly for global markets is estimated to clock a CAGR of 2.5-4.5% during calendars 2024 to 2029. In calendar 2024E, the estimated market size is anticipated to be in the range of Rs 72-82 billion, whereas in calendar 2025E, it is expected to be Rs 72-82 billion market size. Motorcycles (>600 cc) are anticipated to dominate the overal market with more than ~70% overall share, thus reaching a market size of Rs 87-97 billion in calendar 2029P.

Gearbox assembly components for ICE (internal combustion engine) operated motorcycles with more than 600 cc are crucial components since they assist in housing essential components, such as gears, shafts, bearings, and casings, which allows the motorcycle to amplify low-speed torque to facilitate its movement. As manufacturers have started to focus more on producing higher cc motorcycles, thus the need for advanced gearbox assembly components shall see a surge in the coming years leading to significant technological upgradations from the manufacturers. Electrification of motorcycles is less likely to impact the 'greater than 600 cc' segment.

Body components for two-wheelers

Market sizing for body components (CY24E – CY29P)



Note: 1. Above figures comprise of values for India, United States, EU, and ASEAN

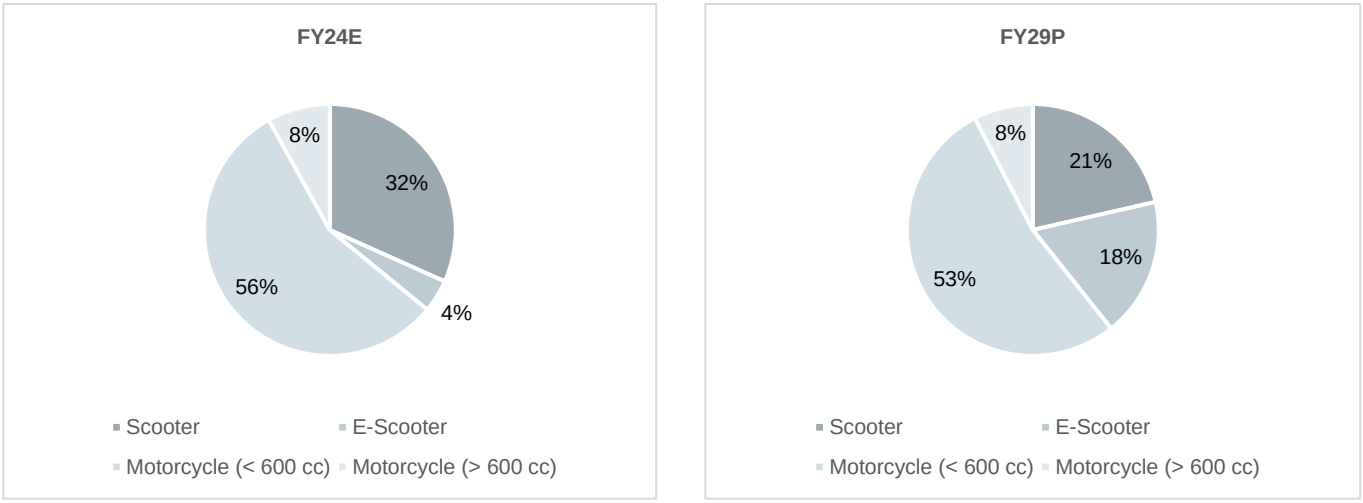
2. Vehicle segments included for market sizing of body components are scooters, e-scooters, and motorcycles

3. Body components segment covers - swing arm, mainstand, chaincase, rims, engine guard, handlebars, sariguard

Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market size of body components is estimated to clock a CAGR of 6-8% during calendars 2024 to 2029. In calendar 2024, the overall estimated market size is anticipated to hover in the range of Rs 445-465 billion, whereas in calendar 2025, it is expected to decline a marginal 0-2%, because of the expected decline in motorcycle volumes. Both global and Indian markets are anticipated to equally drive the body components market with India expected to hold the majority share with ~55-60% and remaing share to be contributed by the US, Europe and ASEAN, and is thus estimated to reach a market size of Rs 640-660 billion in calendar 2029.

Share of vehicle categories for market sizing of body components



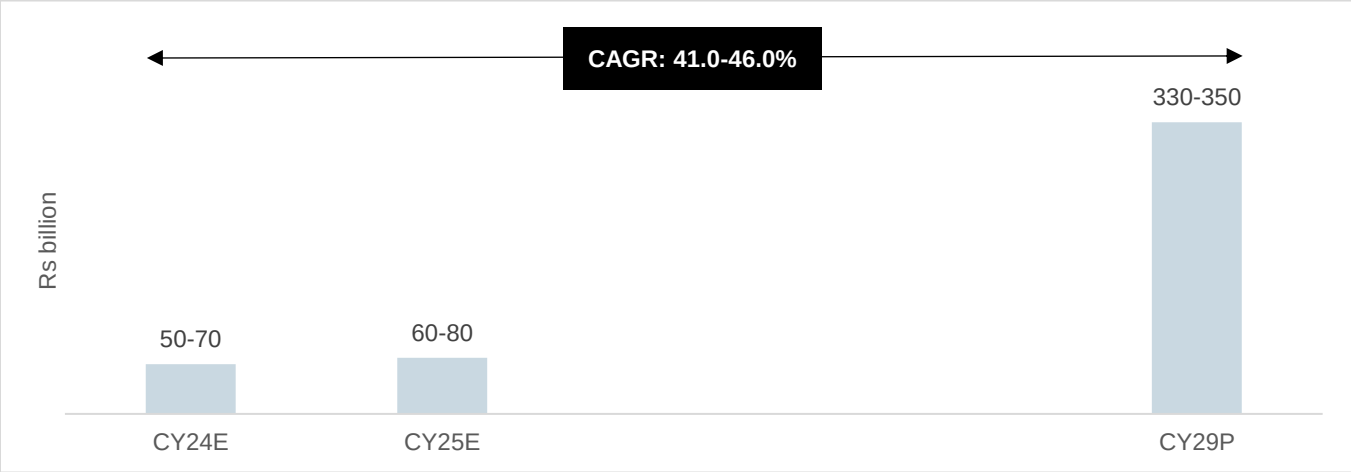
Source: Mordor Intelligence, CRISIL INTELLIGENCE

With the integration of e-scooters in the market and the investment to develop charging infrastructure worldwide, the body-components market for e-scooters is expected to showcase surging growth during the forecast period. The e-scooter industry is expected to grow at a 42-44% CAGR between calendars 2024 and 2029. The share of contribution of motorcycles (both <600cc and >600 cc) is expected to decline marginally, mainly driven by slow growth for 'less than 600 cc' vehicles. However, above 600 cc' motorcycles are expected to grow at a faster rate of 5-7% CAGR between 2024 and 2029, driven by the increasing per-capita disposable income of consumers and the growing preference for availing of luxury motorcycles for aspirational purposes, thus resulting in improved share for the body-components market.

There is a rapid shift toward utilizing lightweight materials to manufacture body components for two-wheelers, which helps in reducing the vehicle weight and carbon emissions. Therefore, two-wheeler manufacturers increasingly prefer aluminium for body components, due to its higher strength-to-weight ratio, heat dissipation, and corrosion resistance. Moreover, the interatom of electric two-wheelers further benefits the demand for advanced body parts and components. A few key manufacturers in India such as Badve Group, Sandhar Technologies, Munjal Auto Industries and Mangum Inc. have played a pivotal role in the growth of the body components industry and have made pioneering advancements to match the industry requirements.

Electric drive motors for e-scooters and e-three wheelers

Market sizing for electric drive motors (CY24E–CY29P)



Note: Above figures comprise of values for India, United States, EU, and ASEAN

Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market size of electric-drive motors is estimated to clock a CAGR of 41-46% during calendars 2024 to 2029. In calendar 2024, the overall estimated market size is anticipated to hover in the range of Rs 50-70 billion. The market is expected to witness a double-digit growth of 12-14% in the calendar year 2025 to Rs 60-80 billion. Faster adoption of electrification in the automotive segment is going to be a key driver for electric-drive motors with major geographies shifting their focus to clean mobility. Owing to that, the market value of electric-drive motors in calendar 2029 is estimated to be in the range of Rs 330-350 billion.

Share of vehicle categories for market sizing of electric drive motors

Source: Mordor Intelligence, CRISIL INTELLIGENCE

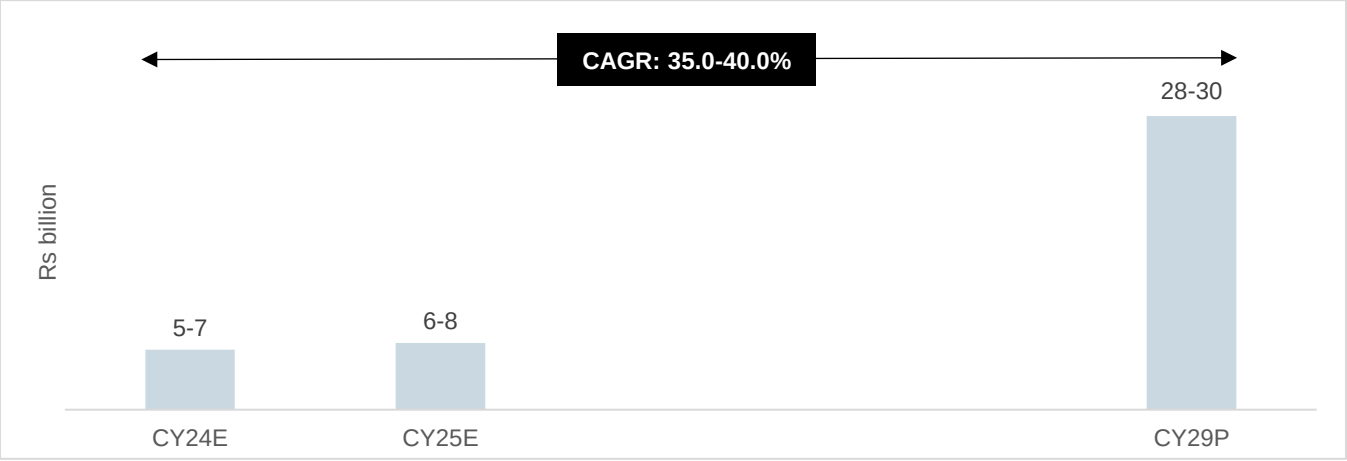
E-scooters is the prominent segment that majorly contributes to the overall market value of electric drive-motors, with over ~90% share both in calendars 2024 and 2029. The e-scooter segment is estimated to witness a robust uptick of a 42-44% CAGR between calendars 2024 to 2030. The rising demand for food-delivery services and the government's

increasing focus on decarbonising the transportation sector are contributing to the growth of the electric-scooters market. The advent and adoption of electric scooters in the market led to an increasing demand for electric drive motors, as they form a crucial component in powering the motion of these scooters. Apart from their usage in the private transportation medium, e-scooters are being increasingly deployed for ride-hailing services, which, in turn, positively impact the growth of electric-drive motors to sustain the rising sales of e-scooters.

Electric three-wheelers are increasingly preferred for last-mile delivery services and passenger transportation. To cater to the growing demand, various component manufacturers are ramping up their production capacity of electric drive motors, which is the key component in these vehicles.

CVT hubs

Market sizing for CVT hubs (CY24E-CY29P)



Note: 1. Above figures comprise of values for India, United States, EU, ASEAN and Japan
2. Vehicle segments included for market sizing of CVT Hubs are bicycles and e-bicycles
Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market size of CVT hubs is estimated to clock a significant CAGR of 35-40% during calendars 2024 to 2029. In calendar 2024, the overall estimated market size is anticipated to hover in the range of Rs 5-7 billion, whereas in calendar 2025, it is expected to hover in the range of Rs 6-8 billion, which is an increase of 11-13% on-year. Increasing global demand for e-bikes is going to be a key driver for the continuous variable transmission (CVT) hubs market. Owing to that, the market value of CVT hubs in calendar 2029 is projected to be in the range of Rs 28-30 billion.

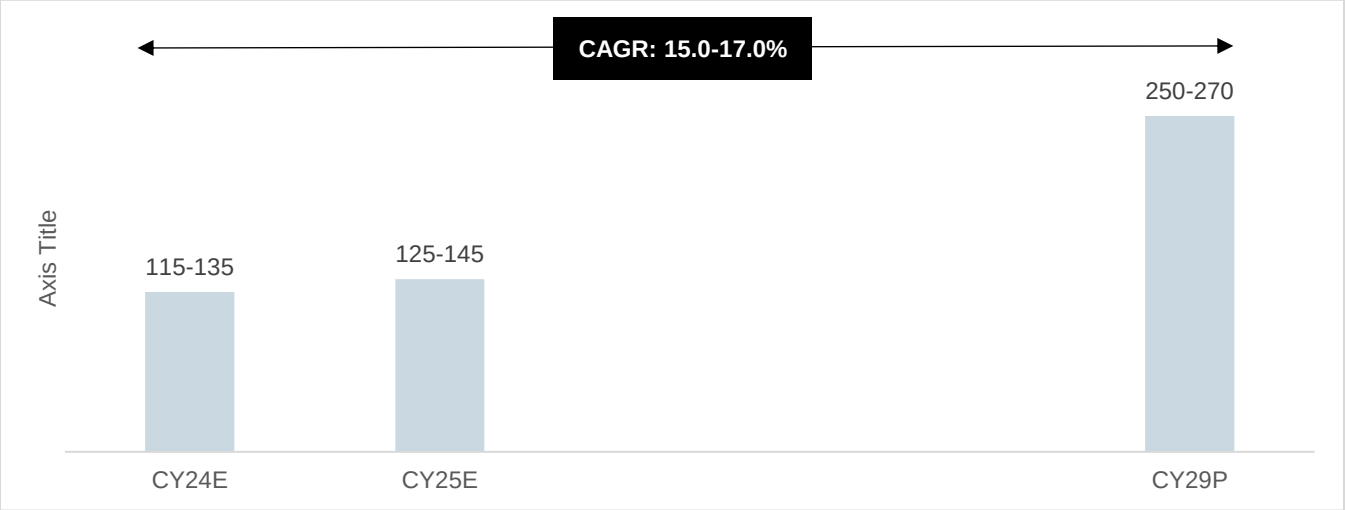
Bicycle riders can choose between a CVT or internal gear hubs that assist in operating these bicycles. Essentially, riders increasingly prefer CVT hubs due to their benefit of automatically changing gears based on speed and the pathway. Furthermore, silent operation makes it a compelling choice for cyclists seeking a hassle-free and enjoyable ride, setting it apart from traditional gear systems that often require manual gear changes, frequent adjustments, and are prone to wear-related issues. With a substantial sale of electric bicycles (10-12% CAGR growth between CY24-29), various manufacturers in the ecosystem are actively strategizing to integrate CVT hubs in their electric bicycles to provide seamless transportation service to customers and enable the incorporation of the latest technology in their products. The growth of CVT hubs is incentivized with the market's shortage of options to meet performance and reliability demands of e-bike riders in current times.

E-CVT system breaks these barriers by combining motor and CVT functionalities at competitive price points, catering specifically to rear-drive motor e-bikes. The hub-motor bicycle market is estimated to grow by 10-12% CAGR during calendar years 2024-2029, thus enabling the fast-paced acceptance of CVT products and resulting in rising penetration level by up to 2.5 times in the coming 5-6 years.

Thus, the increasing popularity of e-bikes, advantages offered by CVT hubs in terms of rider experience and efficiency, and advancements in CVT hub technology leading to potentially lower costs and lighter weight will all contribute to this growth.

Electric drive motors for e-bikes

Market sizing for electric drive motors (CY24E – CY29P)



Note: Above figures comprise of values for India, United States, EU, ASEAN and Japan

Source: Mordor Intelligence, CRISIL INTELLIGENCE

Market size of electric drive motors is estimated to clock a significant CAGR of 15-17% during calendars 2024 to 2029. In CY24E, the overall estimated market size is anticipated to hover in the range of Rs 115-135 billion whereas in calendar 2025E, it is expected to witness a growth of 7-9% on-year. As electric bicycles are experiencing significant change in consumer demographics with an increasing spending capacity of people, the rise of electric drive motor market is inevitable. Thus, the market value of electric drive motors in calendar 2029 is expected to be in the range of Rs 250-270 billion.

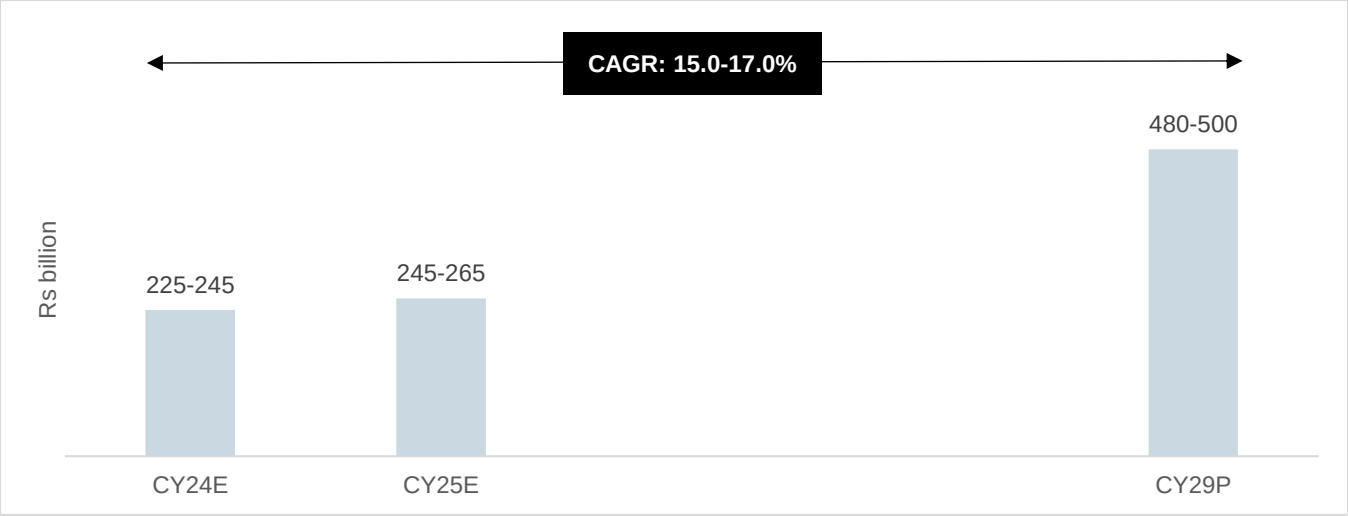
The burgeoning electric bicycle market is acting as a significant catalyst for growth in the electric drive motor market. With consumers' rising preference for healthy living and increasing demand for recreational activities, there is a massive demand for electric bicycles worldwide. Furthermore, this market is undergoing a diversification of styles and functionalities. This encompasses everything from utilitarian cargo bikes to high-performance models, each requiring specific electric drive motors tailored to optimize power, efficiency, and the overall riding experience. This diversification presents exciting opportunities for a wider range of electric drive motor manufacturers to cater to these niche markets. Technological advancements are another key driver of growth. Continuous improvement in electric motor technology is leading to the development of lighter, more efficient, and more powerful motors. Electric vehicles require high efficiency

for improved range and have strict noise, vibration, and harshness (NVH), which is served efficiently by electric motors that are relatively silent and meet NVH requirements.

Cost considerations are a primary concern. Electric drive motors are expensive which adds up to the production costs for manufacturers, potentially impacting the affordability of electric bicycles for some consumers. Despite that, the electric drive motor market for electric bicycles is projected to experience substantial growth in the next five years. This growth will be driven by government's aggressive push toward promoting sustainable mobility and manufacturers investing hefty sums in developing advanced electric bicycle models which will in-turn push motor manufacturers to provide cost-effective customized solutions.

Electric drive unit for e-bikes

Market sizing for electric drive unit (CY24E – CY29P)



Note: 1. Above figures comprise of values for India, United States, EU, ASEAN and Japan

2. Electric drive unit for e-bikes segment covers - Battery, motor and controller

Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market size of electric drive units is estimated to clock a significant CAGR of 15-17% during calendar 2024 to 2029. In calendar 2024E, the overall estimated market size is anticipated to hover in the range of Rs 225-245 billion, whereas in calendar 2025E, it is expected to hover in the range of Rs 245-265 billion. Electric drive units are the primary component of an e-bike consisting of several other components, such as motors, battery and sensors. Thus, the overall growth of EDU depends on the growth of these individual components. The market value of electric drive units in calendar 2029P is expected to be in the range of Rs 480-500 billion.

The e-bikes market is experiencing rapid growth due to increasing demand, but the supply chain ecosystem is still evolving which poses a constraint in finding a comprehensive cost-effective EDU solution. E-Bike OEMs currently procure individual components for these drive units and to ensure seamless operation of the bike, the components must communicate effectively with one another. However, since these components were originally developed independently, it poses a significant challenge for OEMs to achieve the desired integration within the available development timeline. At present, there are few providers offering fully integrated systems, and those that do offer only a limited range of options. Hence, among the crucial components of an e-bike, the drive unit stands out as the most critical. Electric drive units in electric bicycles are the major source that generates power to propel the vehicles without

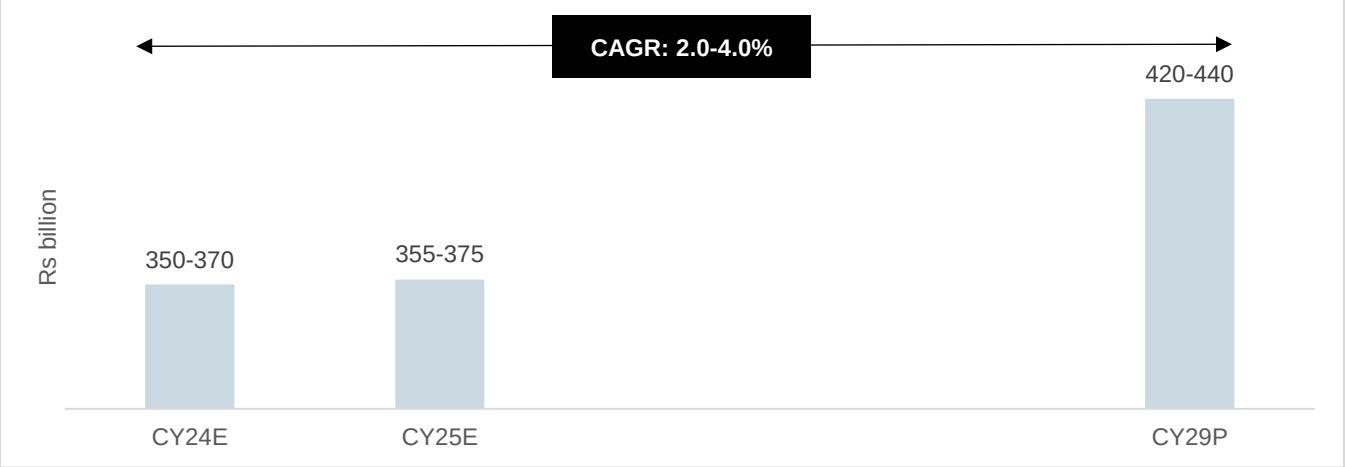
pedaling, such as throttle-based e-bikes. In recent years, an increasing preference for electric-propelled bicycles has contributed to the market's growth.

The global EDU market is not just riding the wave of e-bike popularity in global geographies, technical advancements within EDUs themselves are further fuelling this expansion. Motor technology is at the forefront, with permanent magnet synchronous motors (PMSMs) emerging as a more efficient and powerful alternative to traditional brushed DC motors. This translates to a longer range and improved hill-climbing ability for e-bikes, making them even more appealing to riders. Gearing systems are also evolving. Modern EDUs are becoming increasingly sophisticated with the integration of advanced sensors, such as torque and speed sensors.

Increasing investments by the government to construct pathways specifically for riding bicycles across Europe serve as a significant determinant for the growing sales of e-bicycles. Additionally, the rising preference of consumers for mountaineering and adventurous activities is facilitating the growing sales of e-bicycles since these bicycles help them to utilize less workforce and can easily scale a mountainous road. All these factors will collectively boost demand of electric drive unit in the coming years and providing cost effective solution may help such solution providers to meet the customer requirements and penetrate the market.

Body components for bicycles

Market sizing for body components (CY24E–CY29P)



Note: 1. Above figures comprise of values for India, United States, EU, ASEAN and Japan

2. Body components included for market size are alloy frames, suspension forks, rims, handlebars, seats, grips

Source: Mordor Intelligence, CRISIL INTELLIGENCE

The market size of alloy frames, suspension forks, handlebars, seats, grips is estimated to clock a CAGR of 2-4% during calendars 2024 to 2029. In calendar 2024E, the overall estimated market size is anticipated to hover in the range of Rs 350-370 billion, whereas in calendar 2025E, it is expected to hover in the range of Rs 355-375 billion. As the popularity of e-bikes projects an increasing trajectory along with wider acceptance, these components are going to be directly benefitted, thus taking the market value to Rs 420-440 billion in calendar 2029P.

11. Player profiling of key automotive component companies

Company profiling

CIE Automotive India Limited

Background and overview

CIE Automotive India Ltd. (Earlier known as Mahindra CIE Automotive Limited (MCAL) is part of the CIE Automotive Group of Spain and is the CIE Automotive Groups vehicle for its forgings business globally. The company has 29 manufacturing facilities including 4 manufacturing facilities in Europe and one1 in Mexico. The company, therefore, draws from the vast and varied experience of the CIE group in partnering and co-developing products for the rapidly evolving automotive industry. The company largely operates in the automotive markets of Europe and India. In Europe, the Company supplies components mainly to the light vehicles and heavy truck markets with a comparatively small business in the offroad sector. In India, the company is more diversified and supplies components to the light vehicles segment (both passenger vehicles and light commercial vehicles), two wheelers, tractors, medium and heavy commercial vehicles, in order of dependence.

In calendar 2023, CIE India's consolidated sales (excluding the German forgings operations) were Rs 88,120 million, 7% higher than that in calendar 2022. The company's mitigation plan is to start producing aluminium forged parts and steel suspension products for cars. Almost 40% of the new orders that the car forgings vertical acquired in calendar 2022 were in the BEV space. Forged aluminium parts are expected to constitute a significant part of car forgings sales by 2027. CIE India's European vertical which makes gears for off road and tractors, will not be much affected by electrification. But here too, they have acquired significant business for BEV transmission parts. Electric vehicles will mean a greater emphasis on stamped, plastic, and aluminium parts compared to forged, cast, or machined parts. As the supplier ecosystem for EVs is at a nascent stage, EV Original Equipment Manufacturers (OEMs) are looking to partner with suppliers who have quality and pedigree. Therefore, the transition to EVs may be more of an opportunity rather than a risk.

Endurance Technologies Limited

Background and overview

Endurance is a leading global automotive components manufacturer with a diversified product base including aluminium die castings, transmissions, braking systems, and suspension products. Starting with two aluminium die casting machines in 1985, they have grown to 31 manufacturing facilities strategically located near their Original Equipment Manufacturers (OEMs), in India and overseas. They are known for their aluminium die-casting products and are currently serving the two-wheeler, three-wheeler, and four-wheeler original equipment manufacturers (OEMs). The company also has presence in Europe, through its overseas subsidiaries in Italy and Germany. It is making continuous efforts to increase the share of value-added products in its product mix, including products for EVs. The company's established products of brakings, suspensions, and aluminium die-casting components are EV-agnostic. Endurance markets such EV components to both the established Original Equipment Manufacturers (OEMs) and the new two-wheeler and three-wheeler EV OEMs.

During fiscal 2023, consolidated total income grew by a significant 16.6% over fiscal 2022, mainly on account of the industry growth, order intake, capacity creation, and higher metal prices. Consolidated EBITDA grew by 7.6%, while consolidated EBITDA margin was at 12.2% and net profit grew by 4.1%. Indian operations accounted for 77% of our consolidated total income, and the remainder was from overseas operations.

The company sees huge growth potential in the EV space. Its current EV product portfolio includes suspension front forks and rear shock absorbers, disc brakes, ABS, driveshaft, and different types of aluminium castings, including case transmissions, battery housings, motor housing. To harness the huge EV opportunity, Endurance acquired a 51% equity stake in Maxwell Energy Systems Private Limited and the balance 49% stake will be acquired in a phased manner. Maxwell is in the business of advanced electronics, particularly in the battery management space (BMS) for automobile EVs and stationary storage.

Sona BLW Precision Forgings Limited

Background & Overview

The journey of the company started in 1995 as Sona Okegawa Precision Forgings, which was a 75:25 joint venture between the Sona Group and Mitsubishi Materials and the pioneer of warm forged near net-shaped gears manufacturing technology. The Sona Group, after acquiring Thyssen Krupp's forging business (which acquired BLW, the inventor of warm forging) and 25% stake of Mitsubishi, renamed the company to Sona BLW Precision Forgings, which became a renowned manufacturer of forged gears. In 2019, Sona BLW acquired Comstar Automotive, a designer and manufacturer of starting and charging systems for automobiles and created a new identity.

The company is engaged in the production of differential assemblies, differential gears, conventional and micro-hybrid starter motors, belt starter generator (BSG) systems, electric vehicle (EV) traction motors, such as brushless direct current (BLDC) and permanent magnet synchronous motors (PMSM) and motor control units. Its driveline technology products include precision forged gears and couplings, and e-drive, among others. Its products offer application across various vehicle categories includes electric vehicles, conventional passenger vehicles, commercial vehicles, off-highway vehicles, electric cars, electric light commercial vehicles, and electric two and three wheelers. As of 2023, majority of the company's revenue is generated from the passenger vehicle business (70%), followed by commercial vehicles (14%), off-highway (10%) and electric two-wheelers and electric three-wheelers (6%).

The company's revenue, EBITDA, and PAT have grown 27%, 25%, and 9% respectively in fiscal 2023. The company's BEV revenue share rose to 26%, with a 33% growth in absolute revenue, reaching 67 billion in fiscal 2023. Sona anticipates exponential growth in this domain as both the number of EV programmes and EV customers globally have increased 1.4 times compared with the previous year, now totalling 42 programmes and 26 electric vehicle customers, respectively.

Uno Minda Limited

Background & Overview

Uno Minda Group started its journey in the year 1958, which subsequently led to establishment of Uno Minda Limited ('Uno Minda' or 'The Company') in 1992. They are a prominent manufacturer and supplier of proprietary automotive solutions and systems to Original Equipment Manufacturers (OEMs). The company has a well-diversified product portfolio with client base, both globally and domestically. Over years, the company has diversified its products (acoustics, switches, castings, lighting, seatings, and others), segments (four-wheeler, two-wheeler, three-wheeler & commercial vehicle) and geographies (international and domestic) and channels (replacement & OEMs). Uno Minda

have also built formidable electric vehicle specific products portfolio, leading the automotive industry transition into electric mobility. The company manufactures and supplies over 20 categories of automotive components and systems to leading Indian and international OEMs based in India, Asia, South and North America and Europe.

The company demonstrated excellent performance with 35% growth in annual revenue to Rs 112.37 billion in fiscal 2023 as against Rs 83.13 billion in the previous fiscal. EBITDA for the same period in fiscal 2023 was Rs 12.42 billion compared with Rs 8.85 billion in fiscal 2022. EBITDA margin was higher at 11.1% in fiscal 2023, as against 10.7% in in the previous fiscal, due to benefits of operating leverage, partially offset by higher material costs. As the adoption of electric vehicles grows, the distribution networks for automotive electrical systems will progress. Uno Minda has a diverse product portfolio catering to both global and domestic markets. Uno Minda has been steadily expanding its footprint by adding capacity, products and channels while focusing on infrastructure, technology and research and development. The company has a robust in-house product development capability including localisation of products, aided by a team of over 1000 engineers, filling more than 375 patent applications and over 340 design registrations.

Varroc Engineering Limited

Background & Overview

Varroc Engineering Limited is a global tier-1 automotive component company who commenced operations in India with polymer business in 1990. The company designs, manufactures, and supplies exterior lighting systems, plastic and polymer components, electrical-electronics components, and precision metallic components to passenger car, commercial vehicles, two-wheelers, three-wheelers and off-highway vehicle OEMs directly worldwide.

Varroc's strong R&D capabilities and technological partnership has helped it to develop products and serve customers as per the emerging mega trends of safer, greener, smarter and connected vehicles in automotive space. With over three decades of relentless commitment to excellence and performance, Varroc offers the best design solutions that provides its customers a competitive edge in its markets.

Consolidated revenue from continued operations was Rs 68.73 billion in fiscal 2023, registering a growth of 17.4% on-year. Consolidated EBITDA margin for continued operations for fiscal 2023 was 8.1%, up 175 bps on-year. The group filed 15 patents during fiscal 2023. The company has also commercialised its products developed by its R&D, such as electronic fuel injection (EFI) for ICE vehicles, and various products, such as traction motors, traction controllers, transmission control unit (TCU)s, and DC-DC convertors for electric vehicles.

Hero Motors Ltd.

Background & Overview

Hero Motors is a part of HMC group, led by Mr. Pankaj Munjal. It is one of India's leading automotive technology companies designing, manufacturing, and supplying highly engineered powertrain[2] solutions catering to automotive OEMs in US, Europe, India and ASEAN regions. It is amongst the few companies in India that operates an international product development and design center.

Their powertrain solutions segment is operated as two sub-units based on end applications served, namely, Gears and Transmissions (G&T), serving a wide range of automotive and other mobility applications, and Bike Powertrain (BPT),

[2] *Powertrains are integrated systems designed to propel a vehicle by converting energy into motion. They include the engine or motor, energy storage systems, the transmission, driveshaft, and other related components that work together to deliver power to the vehicle's wheels.*

focused on the applications for the micro-mobility sector, i.e., small, lightweight vehicles like e-scooters, bicycles, and e-bikes used for short-distance travel in urban areas.

Their components cater to various vehicle segments, such as two-wheelers, passenger vehicles, e-bikes and ATVs. In two-wheelers, Hero Motors is among the few companies in India with a global and premium[3] customer base that includes companies like Ducati, Harley Davidson, and BMW to name a few. Over the past five years, the company has expanded its market presence across automotive segments and has grown to become one of the preferred choices for premium two-wheeler OEMs[4] globally. Hero Motors is recognised for its leadership in the development and production of continuously variable transmission (CVT) technology, electric vehicle transmissions, electric motors, integrated drive units and gear sets. The company's expertise in precision gear components and the full transmission system experience, powertrain neutral[5] A&M products, has developed them as one of the few players in India to benefit with the accelerated electrification trends.

Hero Motors is the only player manufacturing and exporting CVT hubs to the global e-bike OEMs from India and are the only manufacturer of integrated electric powertrain products for e-bikes in India. It was among the first companies in India to capitalise on the global e-bike powertrain opportunity and has a distinct first-mover advantage in this industry.

Beyond electric vehicles, Hero is among the few companies that addresses requirements of the premium ICE and performance ICE segment that require high-performance transmission systems capable of handling tough torque needs while keeping components lightweight.

The company's joint venture, HYM Drive Systems (HYM), is of one the companies in the global hub motor product segment, where two automotive brands are combined to develop high-quality products.

To expand its presence in the UK, Hero Motors acquired a strategic stake in the UK-based company called, Hewland Engineering, in fiscal 2021 and majority stake in fiscal 2023. The UK company specialises in transmission design technology and has an established motorsport customer base. The company's revenue from operations increased from Rs 9,142 million in fiscal 2022 to Rs 10,644 million in fiscal 2024, growing by 16.43%. They are one of India's leading solutions providers to the global e-mobility[6] industry, with their revenue from sales to the e-mobility industry as a percentage of total revenues being 19.58% in fiscal 2022, 22.10% in fiscal 2023, and 12.03% in fiscal 2024.

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3 The Premium/High Performance ICE Segment includes vehicles known for their luxury features or strong performance, sometimes both. These vehicles are designed to offer a satisfying driving experience, featuring powerful engines, advanced technology, quality construction, and comfortable user experience. Generally, motorcycles with engine sizes over 600cc and cars with engine sizes above 2 liters fall into this category

4 Premium OEMs in the two-wheeler segment refers to manufacturers who position their vehicles at the higher end of the market in terms of quality, features, and pricing. These OEMs typically offer vehicles with advanced technology, superior performance, and luxurious amenities compared to mainstream or budget brands. Examples of premium OEMs in the two-wheeler segment include Harley-Davidson, Ducati, BMW Motorrad, Triumph, and Yamaha's higher-end models, among others.

[5] ***Powertrain Neutral Components**: Powertrain Neutral components refer to vehicle components that are not specific to a particular type of powertrain (internal combustion engines, electric motors, or hybrid systems). These components are used across the vehicles with different types of powertrains.*

[6] ***E-mobility**: E-mobility encompasses electric-powered transportation, including vehicles like e-bikes, cars, buses and aircrafts.*

Operational parameters

Player-wise financial comparison - Business segments (domestic)

1. Uno Minda Limited

Uno Minda Limited			
Business Segment	**FY22**	**FY23**	**FY24**
Switches	29.00%	29.00%	26.00%
Lighting	22.00%	23.00%	24.00%
Castings	16.00%	19.00%	20.00%
Acoustic	8.00%	7.00%	6.00%
Seating	11.00%	9.00%	8.00%
Others	14.00%	13.00%	16.00%

Note: The percentages mentioned above are reported in the company's investor presentations

Source: Company Investor presentations, Crisil Intelligence

2. Varroc Engineering Limited

Varroc Engineering Limited			
Business Segment	**FY22**	**FY23**	**FY24**
EBU	19.80%	22.00%	37.80%
PBU	33.10%	32.50%	32.30%
Aftermarket	8.50%	8.60%	8.40%
MBU	12.00%	12.10%	11.90%
Others	26.60%	24.80%	9.60%

Note: The percentages mentioned above are reported in the company's investor presentations

Note: EBU – Electrical and Electronics Business Unit; PBU – Polymer Business Unit; MBU – Metallic Business Unit

Source: Company Investor presentations, Crisil Intelligence

3. CIE Automotive India Limited

CIE Automotive India Limited				
Business Segment	**CY21**	**CY22**	**CY23**	**CY24**
Forging	33.00%	37.00%	38.00%	37.00%
Stampings	21.00%	20.00%	20.00%	21.00%
Aluminium	22.00%	19.00%	18.00%	19.00%
Castings	12.00%	12.00%	11.00%	11.00%
Gears/Machining	7.00%	6.00%	6.00%	6.00%
Others	5.00%	6.00%	7.00%	6.00%

Note: The percentages mentioned above are reported in the company's investor presentations

Source: Company Investor presentations, Crisil Intelligence

4. *Endurance Technologies limited*

Endurance Technologies limited			
Business Segment	**FY22**	**FY23**	**FY24**
Die Casting	47.50%	43.80%	42.50%
Suspension	28.00%	27.00%	25.50%
Disc Brake	7.80%	9.50%	11.20%
Alloy Wheel	5.20%	6.90%	7.60%
After Market	5.50%	5.30%	5.30%
Transmission	5.00%	5.20%	4.50%
Others	1.00%	2.30%	3.40%

Note: The percentages mentioned above are reported in the company's investor presentations

Source: Company Investor presentations, Crisil Intelligence

5. *Sona BLW Precision Forgings Limited*

Sona BLW Precision Forgings Limited			
Business Segment	**FY22**	**FY23**	**FY24**
Differential Assembly	27.00%	23.00%	24.00%
Micro/Plug-in Hybrid Starter Motors	26.00%	21.00%	24.00%
Differential Gears	25.00%	32.00%	32.00%
Conventional Starter Motors	17.00%	15.00%	10.00%
Other Drivetrain Parts	3.00%	4.00%	3.00%
Traction Motors & Controllers	1.00%	4.00%	5.00%
Others	1.00%	1.00%	2.00%

Note: The percentages mentioned above are reported in the company's investor presentations

Source: Company Investor presentations, Crisil Intelligence

Player-wise financial comparison - Geography wise Revenue from operations (domestic)

Uno Minda Limited (figures in Rs. Million)			
Geography	**FY22**	**FY23**	**FY24**
India	67,986.30	95,567.80	120,641.80
Global	15,143.70	16,797.10	19,667.10
Total	**83,130.00**	**112,364.90**	**140,308.90**

Note: Consolidated financials are considered for all the companies.

Source: Company reports, Crisil Intelligence

Varroc Engineering Limited (figures in Rs. Million)			
Geography	**FY22**	**FY23**	**FY24**
India	47138.40	55963.09	63947.10
Asia Pacific	2508.65	2455.47	1834.77
Europe	6696.58	7802.02	6030.14
North America	590.11	523.95	758.00
Others	1508.27	1886.13	2949.36
Total	**58442.01**	**68630.66**	**75519.37**

Note: Consolidated financials are considered for all the companies.

Source: Company reports, Crisil Intelligence

CIE Automoive India Limited (figures in Rs. Million)				
Geography	**CY21**	**CY22**	**CY23**	**CY24**
India (including Mexico)	43610.84	45515.60	52898.00	60955.68
Europe	40256.16	42014.40	39905.51	28685.02
Total	**83867.00**	**87530.00**	**92803.50**	**89640.70**

Note: Consolidated financials are considered for all the companies.

Source: Company reports, Crisil Intelligence

Endurance Technologies Limited (figures in Rs. Million)			
Geography	**FY22**	**FY23**	**FY24**
India	54706.06	64731.58	75819.36
Outside India	20785.34	23308.88	26589.35
Total	**75491.40**	**88040.46**	**102408.71**

Note: Consolidated financials are considered for all the companies.

Source: Company reports, Crisil Intelligence

Sona BLW Precision Forgings Lmited (figures in Rs. Million)			
Geography	**FY22**	**FY23**	**FY24**
India	8030.55	10848.36	11797.43
North America	5841.26	10267.69	11043.96
Europe	3157.64	3594.39	6729.74
Asia (excluding India)	3246.06	957.36	1094.86
Others	1030.89	882.30	1181.71
Total	**21306.40**	**26550.10**	**31847.70**

Note: Consolidated financials are considered for all the companies.

Source: Company reports, Crisil Intelligence

Research & Development Expenditure

Companies	R&D Expenditure - FY22 (in Rs. Million)	R&D Expenditure - FY23 (in Rs. Million)	R&D Expenditure - FY24 (in Rs. Million)
Uno Minda Limited	1,114.8	1,990.4	2,242.5
Sona BLW Precision Forgings Limited	442	731	793.00
Endurance Technologies Limited	453.43	623.22	697.78
CIE Automotive India Limited*	NIL	NIL	NA
Varroc Engineering Limited	772.25	860.95	1,004.60

Note: Consolidated financials are considered for all the companies.

Source: Company Reports, Crisil Intelligence

12. Threats and Challenges

Demand Side Challenges

1. **Market Fluctuations**
    - Economic Cycles: Economic downturns can lead to reduced consumer spending, impacting demand for bicycles and two-wheelers.
    - Seasonal Variations: Demand can be seasonal, with peaks and troughs that are difficult to predict and manage.
2. **Consumer Preferences**
    - Changing Trends: Shifts in consumer preferences, such as a move towards electric vehicles or alternative modes of transportation, can affect demand.
    - Quality Expectations: Increasing consumer demand for high-quality and reliable components can pressure manufacturers to improve their offerings.
3. **Competition**
    - Market Saturation: High competition in the market can lead to price wars, reducing profit margins.
    - New Entrants: Entry of new competitors with innovative products can disrupt market dynamics.
4. **Technological Advancements**
    - Innovation: Rapid advancements in technology can render existing products obsolete, requiring continuous innovation.
    - Adoption Rates: Slow adoption of new technologies by consumers can delay market growth.
5. **Regulatory Changes**
    - Emissions Standards: Stricter emissions and environmental regulations can drive demand towards more efficient or electric components.
    - Safety Regulations: New safety standards can necessitate redesigning, affecting demand for current products.
6. **Distribution Network**
    - Channel Partners: Dependence on distributors and retailers can affect market reach and sales performance.
    - Supply Chain Integration: Inefficiencies in the distribution network can impact the ability to meet market demand promptly.
7. **Global Market Dynamics**

- Trade Policies: Tariffs and trade barriers can affect international demand and market access.
- Currency Fluctuations: Exchange rate volatility can impact pricing and demand in different regions.

8. **Pricing Pressure**
    - Cost Sensitivity: High sensitivity to price changes among end-users can limit the ability to pass on increased costs to customers.
    - Discounting: The need to offer discounts or promotions to stimulate demand can affect profitability.

Supply Side Challenges

1. **Raw Material Availability and Costs**
    - Scarcity: Limited availability of essential raw materials like metals (steel, aluminum, copper) can disrupt production schedules.
    - Price Volatility: Fluctuations in raw material prices can impact manufacturing costs and profit margins.
2. **Supplier Reliability**
    - Quality Issues: Inconsistent quality of supplied materials can lead to defects in final products.
    - Delivery Delays: Unreliable suppliers might fail to meet delivery timelines, causing production halts.
    - Dependency: Over-reliance on a single supplier can be risky if that supplier faces any disruptions.
3. **Global Supply Chain Disruptions**
    - Geopolitical Factors: Tariffs, trade restrictions, and political instability can disrupt global supply chains.
    - Natural Disasters: Events like earthquakes, floods, or pandemics can interrupt supply chain operations.
4. **Logistics and Transportation**
    - Freight Costs: Rising costs of transportation and logistics can affect overall expenses.
    - Infrastructure Issues: Poor transportation infrastructure can delay the supply of raw materials and distribution of finished goods.
5. **Technological Challenges**
    - Integration: Integrating new technologies into the supply chain can be complex and costly.
    - Obsolescence: Rapid technological advancements may render existing equipment and processes obsolete.
6. **Regulatory Compliance**
    - Environmental Regulations: Adhering to stringent environmental regulations can increase operational costs.

- Trade Regulations: Complying with international trade regulations and standards can be challenging, especially when dealing with multiple countries.

7. **Labor Issues**
   - Skilled Workforce Shortage: A lack of skilled labor can hamper production efficiency and quality.
   - Labor Costs: Increasing labor costs can impact the overall cost structure of manufacturing.
8. **Supplier Diversification**
   - Risk Management: Balancing the need for multiple suppliers to mitigate risk against the complexity and costs of managing a diverse supplier base.

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