ELECTRIFYING INDIA:

An Analysis of the Electric Vehicles Market

KIRTANE & PANDIT

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

Abbreviation	Definition
ADAS	Advanced Driver Assistance Systems
BEV	Battery Electric Vehicles
CAGR	Compound Annual Growth Rate
DC	Direct Current
EV	Electric Vehicle
EU	European Union
FCEV	Fuel Cell Electric Vehicle
FAME	Faster Adoption of Manufacturing of Electric Vehicles
gWh	Gigawatt hour
HDV	Heavy-Duty Vehicles
HEV	Hybrid Electric Vehicles
IEA	International Energy Agency
ICE	Internal Combustion Engine
kWh	Kilowatt hour
LDV	Light-Duty Vehicle
mWh	Megawatt hour
NBFC	Non-Banking Financial Corporation
NDC	Nationally Determined Contributions
OEM	Original Equipment Manufacturer
OMC	Oil Marketing Companies
PHEV	Plug-in Hybrid Electric Vehicles
PLI	Production-Linked Incentive
TCO	Total Cost of Ownership
tWh	Terawatt hour
V2G	Vehicle-To-Grid
YoY	Year-on-Year
ZEV	Zero-Emission Vehicle

1. EXECUTIVE SUMMARY

In the fight against climate change, Electric Vehicles (EVs) were recognised as the key technology to decarbonise road transport, which accounts for around 16% of global greenhouse gas emissions. EVs offer a sustainable, energy-efficient, and potentially emission-free alternative to fossil fuel-based Internal Combustion Engine (ICE) vehicles.

Over 90 countries across the globe, including India and the EU, have set targets for net zero emissions by 2040 globally and 2035 in leading markets. Together, these countries account for more than 85% of global emissions and 90% of global GDP. The major contributing factor to this change is the transition to zero-emission vehicles (ZEVs). India, which is the world's third-largest oil importer, announced its target to achieve net zero emissions by 2070 and has also set an ambitious target for the transport sector, aiming to electrify 70% of commercial cars, 30% of private cars, 40% of buses, and 80% of 2-wheelers and 3-wheelers by 2030.

In 2023, 18% of all new passenger cars sold in the world were electric (up from 14% in 2022). A Morgan Stanley report predicts that EVs will account for 26% of global car sales by 2030, surging to 72.2% by 2040 and 81.5% by 2050. China, Europe, and the US are the three largest electric car markets, together accounting for over 95% of global sales in 2022, as per the IEA 2023 report. However, a forecast by Mordor Intelligence suggests that although China is the current world leader in the EV sector, the US has a higher Compound Annual Growth Rate (CAGR) than China and is set to double its share in the global EV market by 2029. In comparison, Indian EV market has a much higher expected CAGR of 49% between 2022 and 2030, according to the Economic Survey 2023.

In 2023, the EV sales volume in India reached 1.5. million, according to data released by the Federation of Automobile Dealers' Association (FADA) – registering a 49.35% year-on-year (YoY) growth over the 1 million EV sales recorded in 2022. EVs made up a 6.38% share of India's total vehicle sales in 2023, with 2-wheelers and 3-wheelers contributing majorly to EV adoption in the country.

In 2022, more than 90% of global sales of light-duty EVs and 70% of heavy-duty EVs were covered by EV-related policies. Global policies supporting EVs typically include fuel economy and pollutant standards, zero-emission vehicle mandates or bans on ICE vehicles, fiscal regimes and taxation policies for fuel and vehicles, and purchase incentives and subsidies. In India, EV policies have been in effect since 2015. Subsidies are offered on the purchase of electric 2-wheelers, 3-wheelers, and cars under the FAME-II scheme. The Government has also offered production-linked incentives to boost domestic manufacturing of EVs. In Delhi, the incentives for EVs and a simplified policy for setting up charging stations have been a success, with Delhi's EV sales in December 2023 accounting for 19.5% of total vehicle sales.

Certain challenges may slow the upcoming EV growth curve, such as limited charging infrastructure, high lithium import prices, and supply chain disruptions. For India, there are additional challenges, such as uncertainties about the subsidies, including the extension of the FAME-II scheme or any announcement regarding a new FAME-III scheme. India also faces challenges such as a lack of infrastructure and charging stations, especially since a majority of the operational charging stations are saturated in urban areas and on highways. As of 2 February 2024, India has 12,146 operational public charging stations as per information provided by the Ministry of Power. There is approximately one EV charging station in India for 135 EVs (as compared to the global average of one charger for 20 EVs). India needs at least 1.32 million charging stations by 2030, considering annual sales of 106 million EVs every year and assuming a requirement of 1 charger per every 40 EVs.

Further, there is a high total cost of ownership for EVs in India, considering that the battery makes up almost 40% of the manufacturing cost of an EV. According to the IEA 2022 report, in 2021, India imported lithium-ion cells worth USD 1 billion, of which more than 95% was imported from Hong Kong and China.

However, in February 2023, India announced its first inferred lithium deposits of 5.9 million tonnes, which could potentially be a game-changer in manufacturing EV batteries indigenously. Once the battery pack prices decrease, the pricing of EVs will reduce, thus driving up EV adoption faster and leading to a cost-effective supply chain for India.

EVs are set to revolutionise the global road transport sector. There are many breakthrough innovations happening across the world that will steer the EV ship safely toward clean road transport. Major innovations in the EV space include battery technology advancements, wireless charging, Vehicle-To-Grid (V2G) technology, Ai-integrated OS, and electrified roads using overhead power lines. Many start-ups in India and public-private partnerships are contributing to the growing Indian EV market. The Government is also helping the cause with new policies on battery recycling, retrofitting old ICE cars to EVs, battery-swapping centres, and installing fast chargers and solar-powered chargers across India's highways and roads. This report tries to map the EV landscape and how multiple players are involved at multiple levels, leading towards the ultimate goal of “Net Zero.”

2. EVs: AN INTRODUCTION

An Electric Vehicle (EV) is a vehicle that uses one or more electric motors for propulsion.

An array of features set them apart from their Internal Combustion Engine (ICE) counterparts. A switch to electric vehicles eliminates the dependency on fossil fuels, thereby contributing to reduced greenhouse gas emissions and reduced pollution. EVs are also equipped with regenerative braking systems that capture and convert kinetic energy back into stored electricity, thus reducing energy wastage as compared to friction braking and extending driving range.

EV Technology

At the heart of the EV is the electric motor, the power electronic controller, the battery pack, and the battery management system.

The power electronic controller is responsible for converting and controlling the flow of electric energy and includes an inverter, converter, and an onboard charger.

The electric motor converts power from the battery into mechanical energy.

An EV battery is typically a lithium-ion battery designed for a high power-to-weight ratio and energy density. The battery makes up a significant portion of the cost, weight, and even the environmental impact of an EV. The Tesla Model S has a battery capacity of around 100 kWh, which provides a range of around 570 km on a full charge.

The EV transmission system transfers the power generated by the traction motor to the drive wheel via the gearbox.

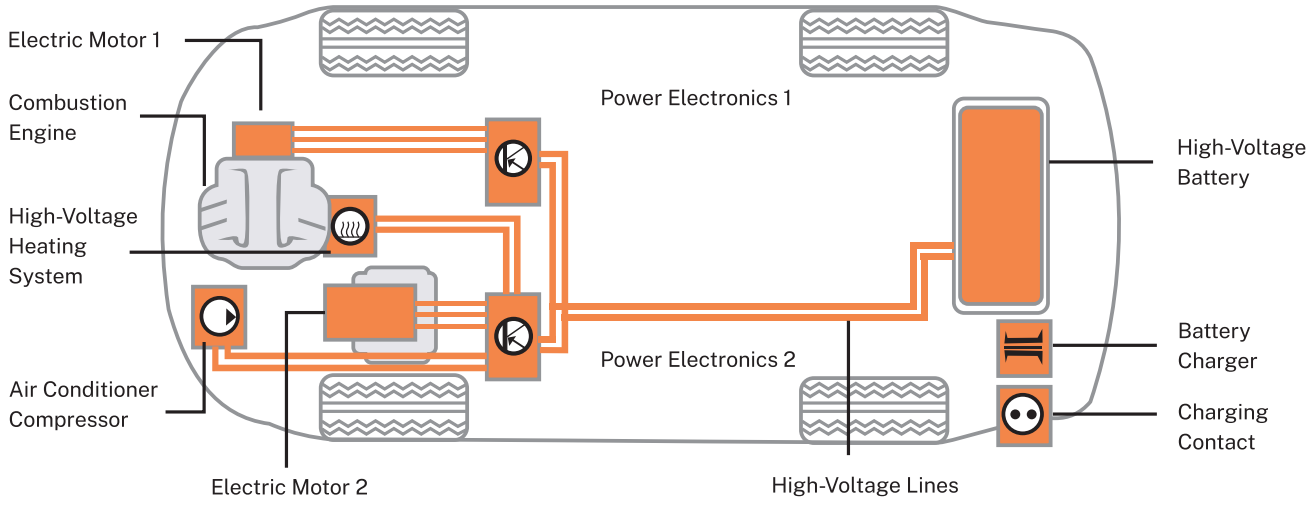


Figure : Components of an EV
Source: ScienceDirect

EV Benefits

Zero Tailpipe Emissions	All-electric vehicles produce no tailpipe emissions.
Lower Carbon Footprint	Studies have shown that EVs typically generate fewer carbon emissions during production and over the lifetime of the EV as compared to ICE vehicles. Even considering electricity production, petrol or diesel vehicles emit almost 3 times more carbon dioxide than the average EV, according to the Government's e-AMRIT (Accelerated e-Mobility Revolution for India's Transportation) portal. The carbon footprint of EVs can be further lowered by switching to renewable energy sources for charging.
Convenient Charging	An EV can be recharged at home or at public charging stations, thereby eliminating petrol station visits entirely. The average recharge time using a Level 2 (AC) charger is 4-10 hours. Fast (DC) chargers bring down the charging time to 20-60 minutes, but they are more expensive than Level 1 and Level 2 chargers.
Energy Efficiency	EVs boast remarkable energy efficiency, converting 59-62% of grid energy to power at wheels, as against petrol ICE vehicles which convert only 17-21% of the energy stored in fuel power at wheels.
Silent and Smooth Operation	EVs operate quietly and smoothly, offering fine control and high torque from a standstill. This eliminates the need for gearboxes and torque converters. EVs also contribute to reducing noise pollution, which ICE vehicles contribute to.
Low Running and Maintenance Costs	EVs have much lower running and maintenance costs than ICE vehicles. According to the Consumer Reports 2023, electric cars are 60% less expensive to power and 50% less expensive to maintain and repair than gasoline vehicles.
Advanced Software and Technology	EVs are equipped with sophisticated software and operating systems that provide technological benefits to consumers, including remote monitoring, over-the-air updates, and smart charging features. Tesla's Autopilot uses AI to provide features such as adaptive cruise control, self-parking, etc.

EV Drawbacks

While EVs are undoubtedly the future of automobiles, the EV ecosystem still has a long way to go and is not without its drawbacks.

High Costs	EVs often come with a higher upfront price than ICE vehicles, because of the high cost of battery technology.
Limited Range	Although EVs are continuously improving in terms of range, they may still not be suitable for long-distance travel, especially in regions with limited charging infrastructure. Currently, the average range of EVs is about 200 to 500 km on a single charge.
Cold Climate Energy Consumption	In cold climates, EVs may consume more energy to provide heating for passenger comfort, reducing their overall range on a single charge.
Charging Infrastructure	In many countries, the EV ecosystem is still developing, and charging infrastructure is limited. Even in India, public charging stations are not yet widely available, which makes extended journeys challenging.

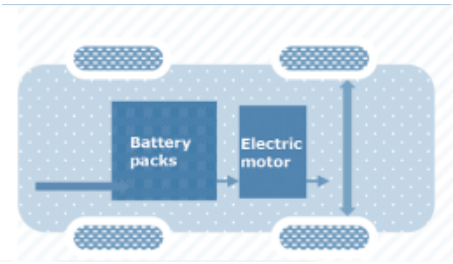
Types of EVs

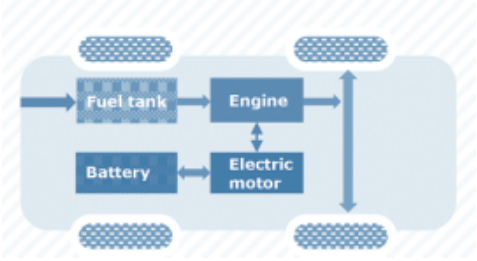
EVs can be all-electric, or they can be 'hybrids' which have an ICE engine alongside an electric motor, thereby alleviating range anxiety and charging issues.

Classification by Engine Type

Battery Electric Vehicles (BEVs): BEVs, or pure-electric vehicles, are powered solely by electric motors. The electricity usually comes from a battery. In the case of solar vehicles or fuel cell vehicles, the electricity is generated via solar energy or from a hydrogen fuel cell.

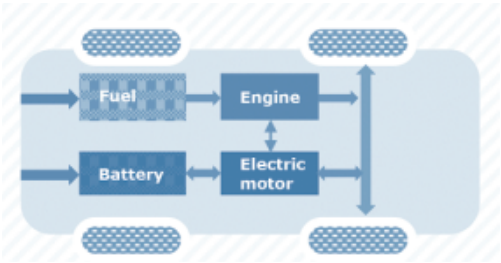
Hybrid Electric Vehicles (HEVs): HEVs combine an electric motor with an ICE engine, where the electric motor is intended to achieve better fuel economy and reduce emissions. The car switches to the petrol or diesel engine when the battery is not charged.

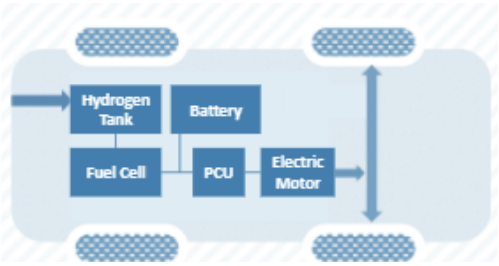




Plug-in Hybrid Electric Vehicles (PHEVs): PHEVs use electric propulsion as the main driving force. For high-speed driving or for extended journeys, the ICE engine kicks in. The two drivetrains can be used together to improve performance. PHEVs are more efficient than HEVs.

Fuel Cell Electric Vehicle (FCEV): FCEVs generates electricity through chemical energy using a fuel cell. Most FCEVs are powered by hydrogen, which is stored in a tank on the vehicle and is converted to electricity by the fuel cell. There are only a few FCEV models in the market due to limited hydrogen infrastructure.





Classification by Vehicle Size

A typical categorization by vehicle size in the US and European markets is Small Car, Medium Car, Large Car, SUV, Truck, and Bus. 2-wheeler and 3-wheeler EVs are more prominent in Asian markets, especially China and India.

EV Sales in India in 2023 (categorized by vehicle size):

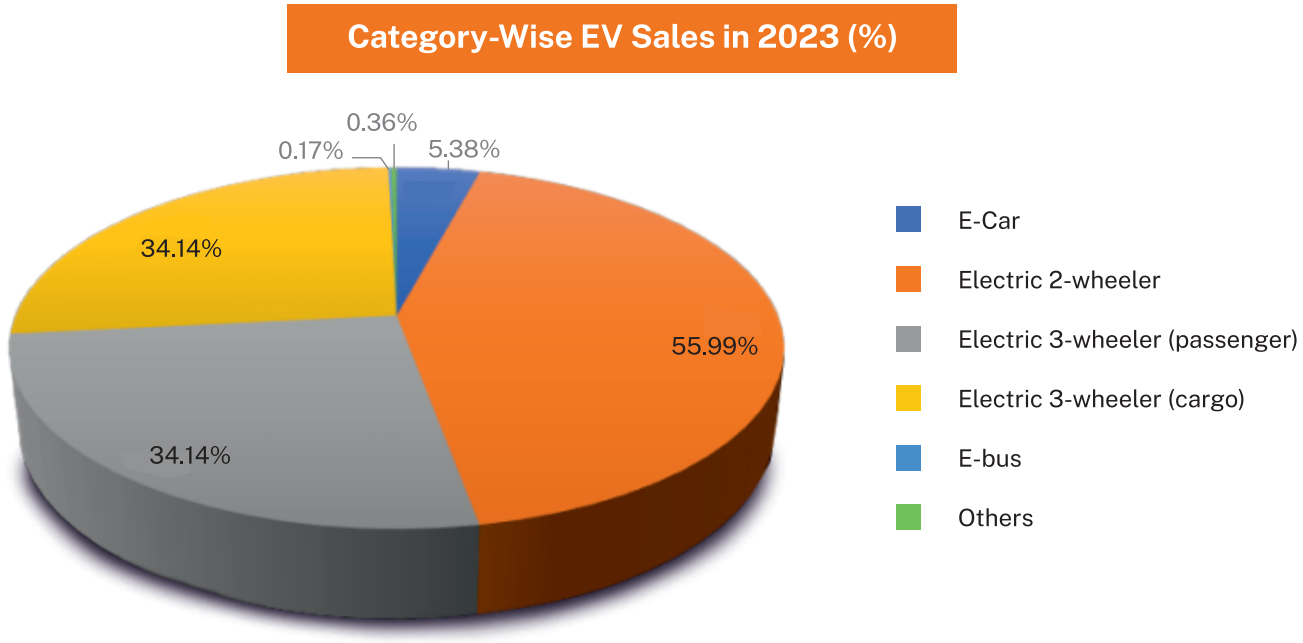


Figure : EV Sales in India in 2023
Source: Vahan Dashboard, JMK Research

Classification by Transport Type

- **Ground Vehicles:** Ground vehicles include BEVs and PHEVs, including electric bicycles, 2-wheelers, 3-wheelers, cars, trucks, and buses.

- **Rail EVs:** Electric trains are becoming increasingly popular for intercity travel, especially in Asia and Europe. Rail lines are relatively easy to power through permanent overhead lines or electrified third rails.

- **Seaborne EVs:** Electric boats were popular in the 20th century. Today, electric ferries and cargo ships are emerging as sustainable alternatives for maritime transportation.

- **Airborne EVs:** Crewed flights in an electrically powered airship date back to the 19th century. The Velis Electro became one of the first types of certificated crewed electric aircraft on 10 June 2020. Today, most crewed electric aircraft are experimental prototypes. However, electric drones are presently revolutionising aerial delivery and transportation.

History of the Electric Vehicle

Although EVs have gained huge traction in the 21st century, the invention of the electric car, in fact, precedes Internal Combustion Engines (ICEs). The first successful electric automobiles appeared in the late 19th century. In fact, one of the first Porsche cars was a hybrid electric car!

Timeline:

1827: The electric motor is invented.

1832 to 1839: Robert Anderson invents the first crude electric carriage. Other small electric cars are also experimented with during this period.

The early 1900s: The first mass-produced electric vehicles appear in the US. In 1900, 28% of cars in the US were EVs. President Woodrow Wilson and his secret service agents toured Washington, D.C., in their Milburn Electrics, which covered 100–110 km per charge.

1910s: Huge petroleum reserves are discovered worldwide, leading to the availability of cheap gasoline.

1912: The electric starter is invented to replace the crank starter for gasoline cars.

1913: Henry Ford begins mass production of ICE cars.

Early 1920s: The popularity of electric cars plummets, and ICE cars become convenient and affordable. According to the US Department of Energy, in 1912, the price of a gasoline car was only USD 650, while an electric roadster sold for USD 1,750. Over the next 30-50 years, electric cars become a niche, with a few enthusiasts keeping the flame alive.

Early 1970s: An oil crisis begins, causing global gasoline shortages and soaring prices. Fossil fuel alternatives and electric vehicle options are explored, but by the 80s, as fuel prices stabilise, ICEs continue to dominate the automobile sector.

1990s: Interest in EVs gets renewed amidst concerns of peak oil and environmental concerns over petroleum-based transportation. California Air Resources Board mandates major-automaker sales of EVs. GM's EV1 becomes popular (the car featured in the 2006 documentary Who Killed the Electric Car?) until it is discontinued in 2003.

1997: Toyota Prius is introduced, the world's first mass-produced hybrid electric vehicle.

2008: Tesla's Roadster hits the roads - an all-electric luxury sports car with a range of over 320 km on a single charge.

Tesla's innovation and market success served as a catalyst, inspiring other automakers such as Nissan, Chevrolet, and BMW to enter the EV arena. Today, there are over 500 EV models in the world.

3. GLOBAL EV MARKET AND KEY PLAYERS

In 2023, 18% of all new passenger cars sold were electric (up from 14% in 2022).

The global EV market has been growing exponentially in the 21st century. Global EV sales, including passenger and commercial EVs, reached 92 million units in 2023, accounting for an 18% share of global car sales.

2020 was a slow year in terms of global EV sales (5% of global car sales were electric) owing to the COVID-19 pandemic and the economic downturn. The COVID-19 pandemic caused EV production to halt for many months, including for factories that produced EV batteries and other components. At the same time, consumer demand for EVs fell sharply. Despite the dip, China managed to meet its target of 5 million NEV sales by 2020. Europe's EV market also surged in 2020 due to the new CO2 emission standards and EV tax incentives (see Policy Support section below).

In 2021, almost 9% of all global car sales were electric, reaching a volume of almost 6.6 million (as compared to 120,000 units sold in 2012), according to the Global EV Outlook 2022 report by the International Energy Agency (IEA). In other words, more EVs were sold in one week of 2021 than the entire EV sales of 2012.

In the year 2023:

- 18% of all new passenger cars sold were electric, as against 14% in 2022.
- Global EV sales grew by 31% as against a 55% growth rate in 2022.
- The global passenger EV sales volume hit 14 million in 2023 (as against 10 million in 2022). According to Rho Motion, a market research firm, out of this, 9.5 million sales were Battery Electric Vehicles (BEVs), i.e., a 68% share, with Plug-in Hybrid Electric Vehicles (PHEVs) accounting for the rest.
- According to a report by BloombergNEF, global spending on clean road transport reached USD 685 billion in 2023.
- China, Europe, and the US are the three largest electric car markets, together accounting for over 95% of global sales in 2022, as per the IEA 2023 report.

Emerging EV markets include India (covered separately below), Thailand, Indonesia, and Costa Rica:

- In Thailand, electric car sales in 2022 reached 21,000. Notably, Chinese EV models were the most popular cars in Thailand.
- In Indonesia, BEV sales multiplied by more than 14 in 2022. Indonesia has abundant mineral resources, especially nickel, and has announced incentives to support EV sales by strengthening domestic capacity in EV and battery manufacturing.

A Morgan Stanley report predicts that EVs will account for 26% of global car sales by 2030, surging to 72.2% by 2040 and 81.5% by 2050.

Under the IEA Stated Policies Scenario (STEPS), the projected share of electric car sales will be 35% by 2030, with China retaining its position as the largest EV market with a 40% share, the US doubling its share to 20%, and Europe maintaining the current 25% share.

We examine below the key players, EV ecosystem, and pricing economics of these three largest EV markets, namely, China, Europe, and the US.

Market Domination: China, Europe, and the US

According to market research by Mordor Intelligence, during the forecast period 2024-2029:

- China's EV market size is estimated to grow from USD 305.57 billion to USD 674.27 billion, growing at a Compound Annual Growth Rate (CAGR) of **17.15%.**
- The European EV market size is estimated to grow from USD 189.43 billion to USD 406.63 billion, growing at a CAGR of **16.51%.**
- The US EV market size is estimated to grow from USD 92.86 billion to USD 211.32 billion, growing at a CAGR of **17.88%.**
- The above forecast suggests that although China is the current world leader in the EV sector, the US is set to double its share in the global EV market.

China:

According to the China Passenger Car Association, China has overtaken Japan to become the largest exporter of automobiles in the world in 2023.

In 2022, China accounted for more than 60% of all new electric car registrations, surpassing the US, Norway, and other early adopters of EVs. China contributed around 35% to the global EV car exports in 2022. However, Tesla China is estimated to have accounted for almost 49% of such exports, with European / Chinese-owned European EVs accounting for another 49%. In Q4 2023, China's BYD Auto (which is backed by Warren Buffet) surpassed Tesla in terms of passenger BEV sales for the first time.

China is dominating the EV market, with Chinese EVs gaining market share around the world. China is also leading the world in terms of electric bus sales, with an 80% share in global electric bus sales.

Europe:

In Europe, 2020 and 2021 were exceptional growth years for the EV sector, owing to the EU's new CO2 emission standards (which will become stricter from 2025 onwards). In 2022, according to the IEA 2023 report, Europe accounted for 25% of all electric car sales, with electric car sales growing by more than 15% in comparison to 2021.

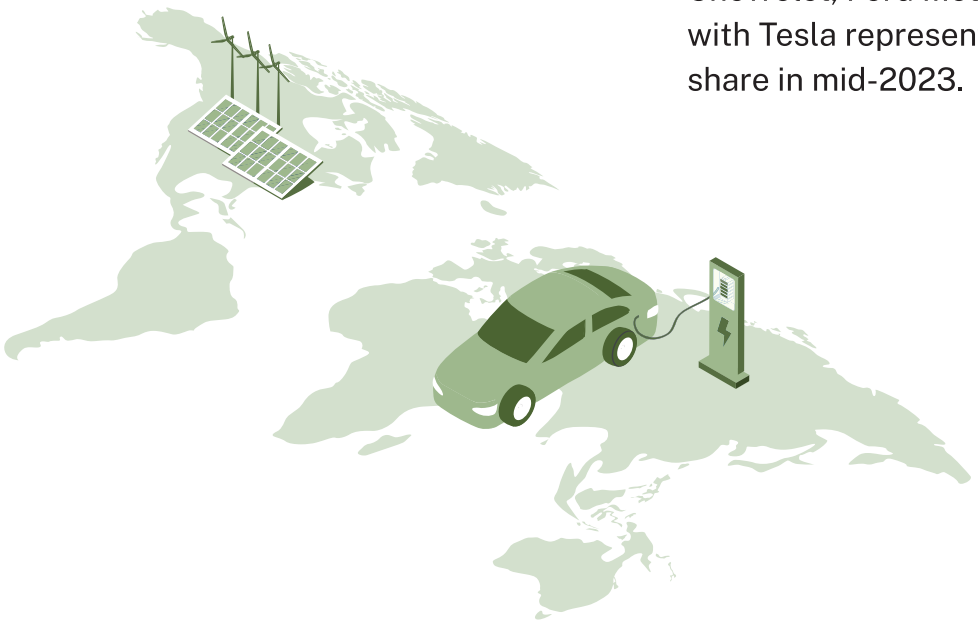
Germany represents the largest EV segment in Europe, with a 35% EV sales share. Norway is leading Europe in terms of highest EV adoption, with a 90% share for BEVs and PHEVs combined.

In Europe, Finland had the highest growth in electric bus sales (over two-thirds share) in 2022, followed by Denmark and the Netherlands.

US:

In 2022, the US accounted for 10% of the global growth in EV sales. US's Inflation Reduction Act, which increased tax credits for qualifying EV purchases, has helped bring EV costs down for buyers, signifying additional growth in the coming years. In April 2023, California achieved 1.5 million EV sales to date.

The US government is offering federal tax credits, subsidies, and incentives to boost the EV market, which is expected to grow in the coming years. The government is also promoting domestic manufacturing of batteries in the US. Tesla accounted for almost 55% of the US EV market in 2023, making for the decline in sales from 65% in 2022 by opting for price cuts on various models.



Key Players

The top Chinese EV automakers include BYD (35% market share), GAC Aion (6.3%), and Li Auto (4.9%). Tesla, which has a manufacturing plant in China, holds a 7.8% market share in China and ranked second after BYD, according to the China Passenger Car Association.

Chinese electric buses are exported to North American and European countries. The key electric bus manufacturers include Yutong, King Long, and BYD. China also dominates the 2-wheeler EVs market. China's largest 2-wheeler companies include Yadea, Aima, and Nio.

In Europe, Ford Motor and General Motors are the high-performance truck market leaders. Audi, BMW, Renault, and Volkswagen are the key players in the passenger and luxury EV segment. China is one of the largest sales markets for several European automakers, such as Volkswagen, BMW, and Mercedes.

In the US, the key players include Tesla, Chevrolet, Ford Motor, Hyundai, and Rivian, with Tesla representing a 60.5% market share in mid-2023.

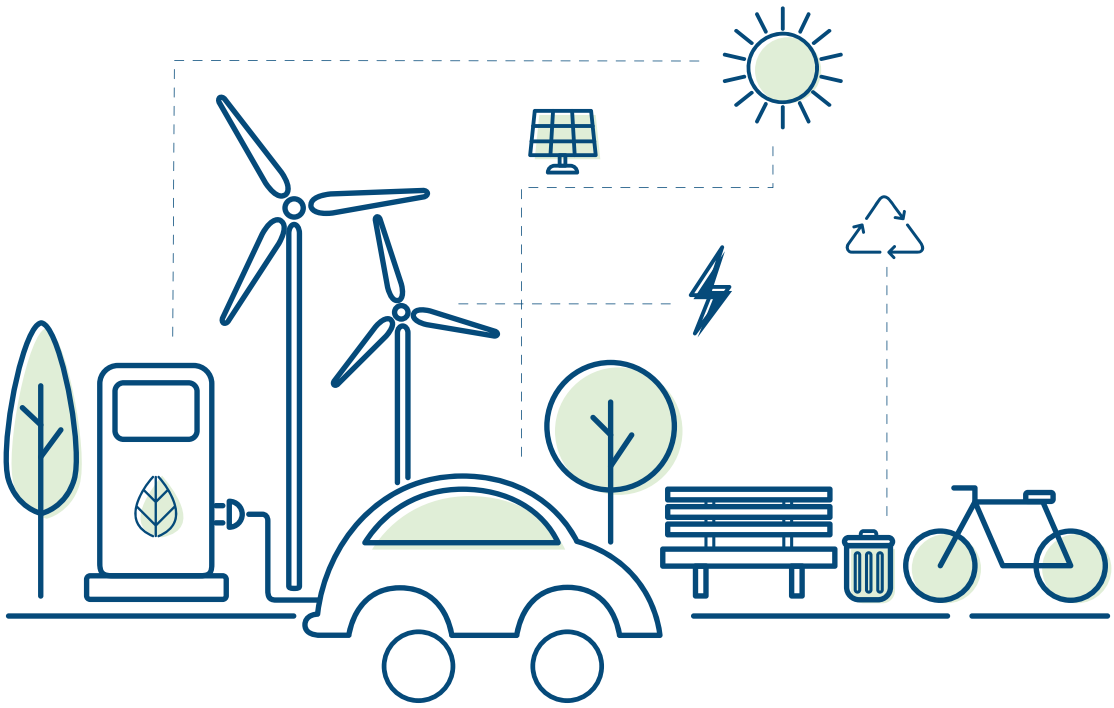
EV Pricing

In the first quarter of 2023, according to Jato Dynamics, the average retail price of an electric car in China (EUR 31,165) was less than half of the average EV prices in Europe (EUR 66,864) and the US (EUR 68,023). Chinese BYD's Atto 3 (which sells in over 50 countries, is priced at EUR 38,000 (as compared to the Tesla Model 3 which is priced at around EUR 43,000).

In Europe and the US respectively, an EV costs 92% and 146% more than the cheapest available combustion engine vehicle. In China, the cheapest EV costs 8% less than the cheapest ICE vehicle.

China has also achieved parity with ICE vehicles in terms of price, quality, and power. In Europe and the US, EVs still cost more than their gasoline counterparts. According to Jato Dynamics, an EV costs 92% and 146% more than the cheapest combustion engine available in Europe and the US, respectively. On the other hand, in China, the cheapest EV costs 8% less than the cheapest ICE vehicle.

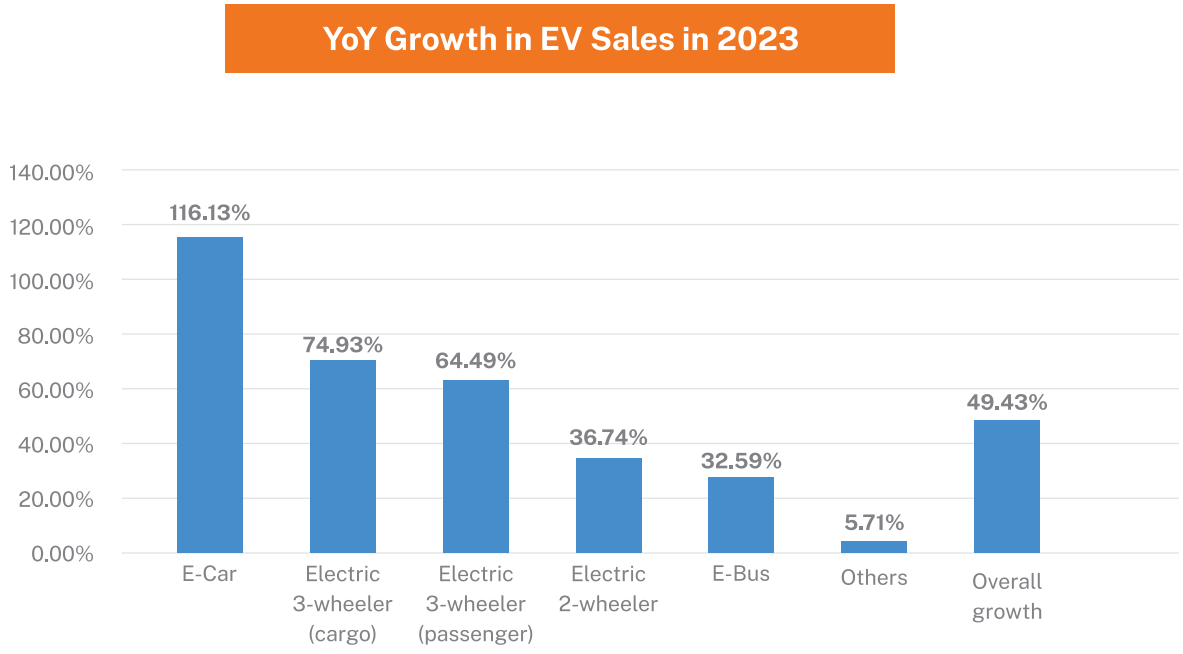
The cheap pricing for EVs in China, coupled with incentives and subsidies, has prompted automakers such as Tesla and Volkswagen to competitively reduce the prices of their models in the Chinese market. The latest price cut for Tesla was announced on 12 January 2024, when the prices for the Tesla Model 3 sedan were slashed by 5.9% in the Chinese market.



4. THE INDIAN EV MARKET

In this section, we examine India's EV market in terms of category-wise growth in 2023, market penetration of EVs, key players, and present scenarios with respect to funding and investment in the sector.

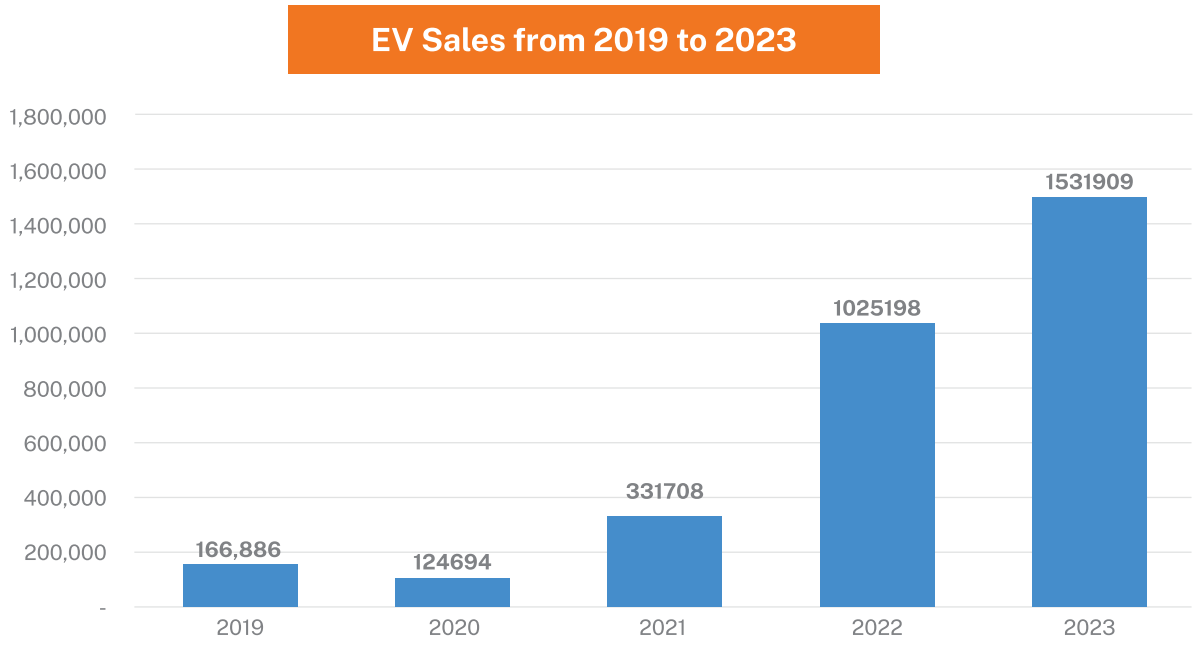
India is already the third-largest automobile market globally in terms of sales. The automotive sector accounts for 7.1% of its GDP. India's vehicles market demonstrated an ~11% year-on-year (YoY) growth over the total vehicle sales recorded in 2022.
In comparison, the EV sales volume in India reached 1.5. million in 2023, according to data released by the Federation of Automobile Dealers' Association (FADA) – registering a 49.43% year-on-year (YoY) growth over the 1 million EV sales recorded in 2022.



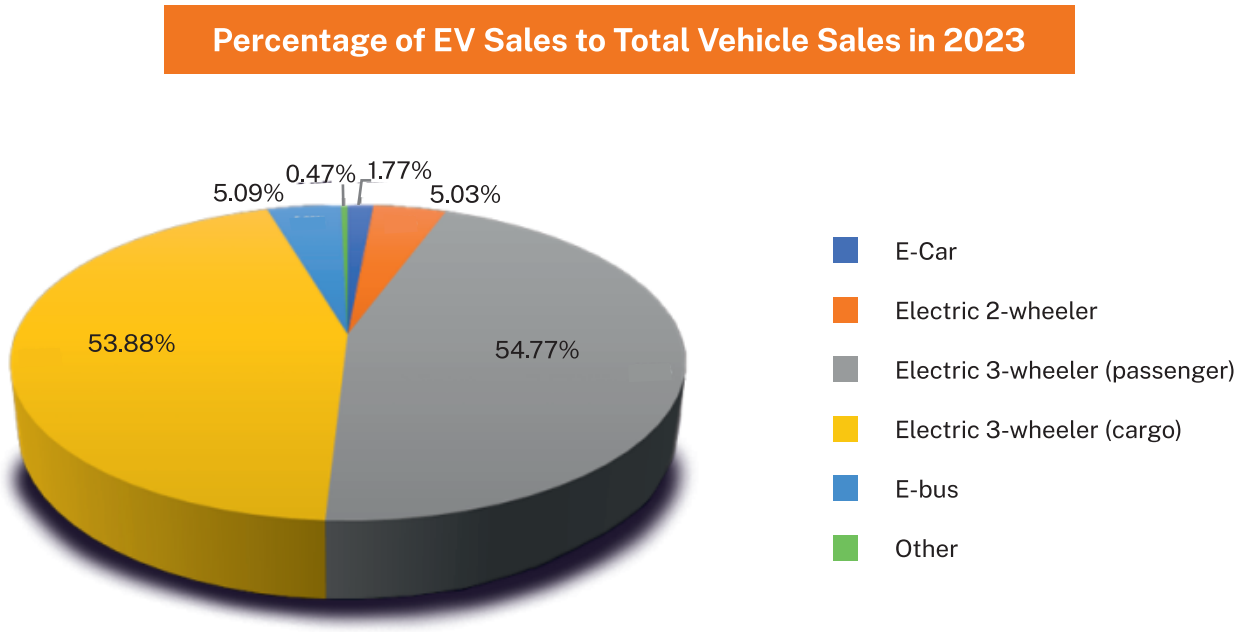
Source: Vahan Dashboard by the Ministry of Road Transport & Highways

As per the Economic Survey 2023, India's EV market will grow at a Compound Annual Growth Rate (CAGR) of 49% between 2022 and 2030, reaching 10 million annual sales by 2030. The EV industry is also projected to create around 50 million direct and indirect jobs by 2030.

There has been significant growth in India's EV sector, particularly in the 2-wheeler, 3-wheeler and e-bus segments as demonstrated by the below chart.



EVs made up a 6.38% share of India's total vehicle sales in 2023.



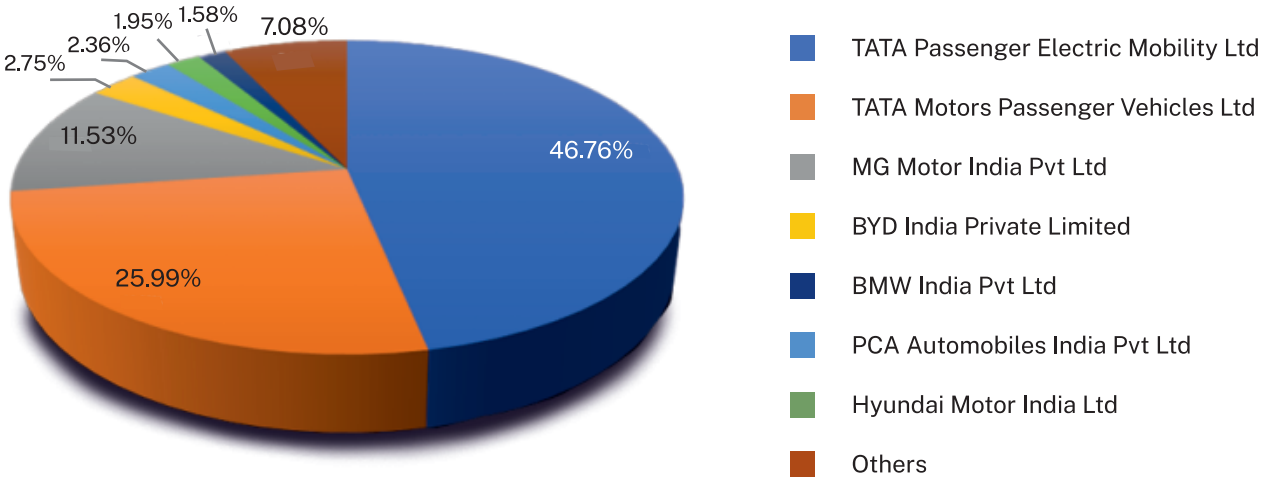
Source: Vahan Dashboard by the Ministry of Road Transport & Highways

An analysis of the above data shows that:

- Over half of India's 3-wheeler registrations in 2023 were electric. According to the IEA, a contributing factor for this may be the fact that electric 3-wheelers in India are already up to 70% cheaper than their ICE equivalents over their lifetime.
- Passenger EVs only make up ~2% of the Indian car market. In 2022, as per the IEA, 25% of electric car purchases in India were for fleet operators such as taxis. In early 2023, Uber placed an order with Tata Motors for 25,000 electric cars.
- The 2-wheeler segment is growing at a steady rate but only accounts for around ~5% of the total 2-wheeler market.
- The e-bus segment is demonstrating steady growth, with a 32.59% Year-on-Year (YoY) growth from 2022.

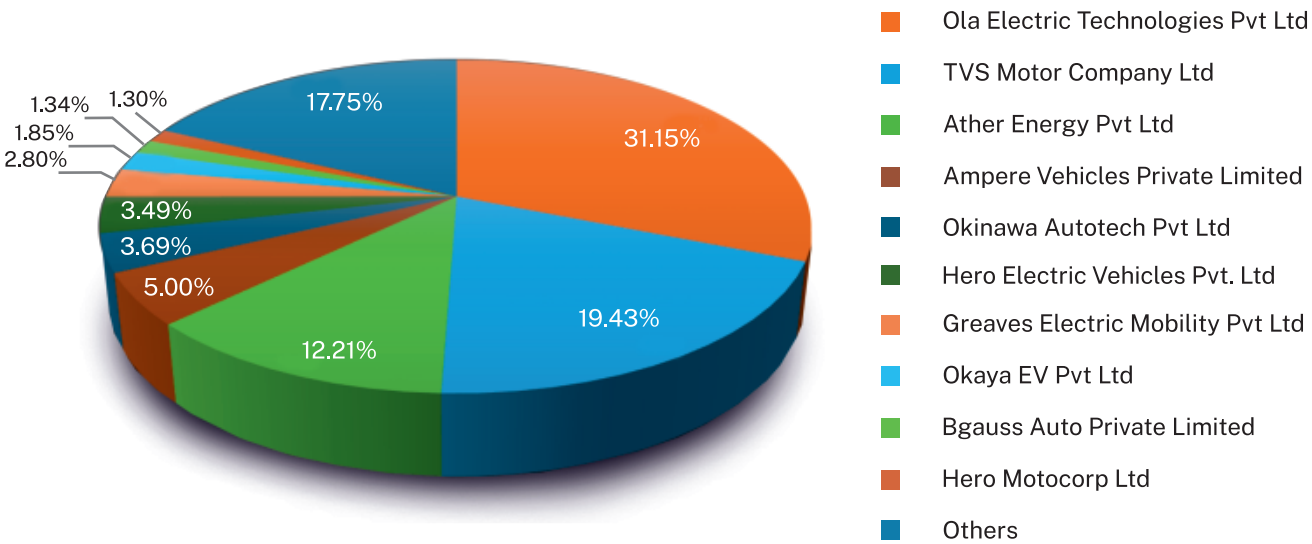
In terms of passenger EVs, there are around 13 EV automakers in India, out of which Tata Motors accounts for ~26% of total e-car sales in 2023, mainly through its bestselling models Tigor, Nexon, and Tiago, followed by MG Motor India's Comet and Hyundai's Kona. Tesla has been attempting to set up a manufacturing plant in India; however, no details have been finalised yet. Vietnam's VinFast has recently announced plans to set up an EV manufacturing plant in Tamil Nadu.

Share of Automakers in e-Car sales in 2023



Ola, the top EV company in India by revenue, is the market leader in the electric 2-wheeler segment, with a 32% market share. Ola has announced plans to start electric cars for its taxi business by 2024. Ola also plans to build lithium-ion battery manufacturing facilities, initially at 5 gWh capacity, scaling up to 100 gWh by 2030.

Share of Automakers in 2-wheeler EV sales in 2023



In December 2023, Indian officials announced that India is engaging with potential investors from Germany, the UK, and South Korea as part of its latest EV policy. A major portion of funding received in 2023 in the EV space has been for OEMs or EV automakers.

The driving factors behind India's growth in the EV sector include the FAME-II subsidy and a Production-Linked Incentive (PLI) scheme for manufacturing EVs and components (see the Policy Support section for details).

EV Pricing

The ex-showroom price of a 4-wheeler EV in India ranges from Rs. 8.69 lakh (Tata Tiago with a range of 315 km) to Rs.65 lakh (Kia EV 6 with a range of 708 km). The average ex-showroom price of a Tata Nexon EV (medium range) is Rs. 14.74 lakh as compared to the average ex-showroom price of a Tata Nexon petrol car, which is priced at Rs. 8.1 lakh (a differential of almost 80%). Even considering other EV models available in India, EVs are still 15-20% more expensive than their ICE counterparts.

The battery pack makes up a major portion of the manufacturing cost of an EV. As per BloombergNEF, in 2023, the average price of a lithium-ion battery pack fell by 14% from 2022 prices. The average pack price in 2023 for a passenger BEV was USD 128/kWh. BloombergNEF expects that the amount will reach USD 100/kWh by 2027 – at which point EVs will achieve price parity with ICE vehicles.

In India, the battery makes up almost 40% of the manufacturing cost of an EV, primarily because India relies heavily on imports of lithium-ion batteries. According to the IEA 2022 report, in 2021, India imported lithium-ion cells worth USD 1 billion, of which more than 95% was imported from Hong Kong and China. In February 2023, India announced its first inferred lithium deposits of 5.9 million tonnes, which could potentially be a game-changer for India's supply chain and for global cell manufacturing.

5. ROADMAP TO ZERO-EMISSION VEHICLES (ZEV)

Net Zero Commitments

The Paris Agreement signed in 2015 called for global temperatures to be limited to 1.5°C above pre-industrial levels to avert the worst impacts of climate change. To achieve this, global emissions need to be reduced by 45% by 2030 and reach net zero by 2050. At the UN Climate Change Conference in Glasgow (COP26) in 2021, over 30 countries and 6 major vehicle manufacturers set out targets for all new car sales to be zero-emission vehicles by 2040 globally and 2035 in leading markets.

Zero-Emission Vehicles (ZEVs) are the key technology to decarbonise road transport, a sector that accounts for around 16% of global greenhouse gas emissions.

As part of the Paris Agreement, India, which is the world's third-largest oil importer, has committed to reducing its greenhouse gas emissions per unit GDP by 33%-35% over 2005 levels by 2030. India, at COP26, announced its target to achieve net zero emissions by 2070. India also targets to achieve about 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

In 2023, the US, Europe, and China together account for 59% of the world's road transport emissions. Although COVID-19 lockdowns caused a dip in transport-related emissions, they rebounded in 2021, growing by 8% from 2020 levels. As of September 2023, over 90 countries and the EU (which cover more than 85% of global emissions and 90% of global GDP) have set net-zero targets, which can be met by strengthening the Nationally Determined Contributions (NDCs).

Where do EVs come in?

EVs are the key technology to decarbonise road transport, a sector that accounts for around 16% of global greenhouse gas emissions. The global transport sector accounts for more than one-third of CO2 emissions. According to the International Energy Agency (IEA) clean energy tracker, if the growth in the electric vehicles sector is sustained, the global CO2 emission from cars can be aligned to the 'Net Zero Emissions by 2050 Scenario'.

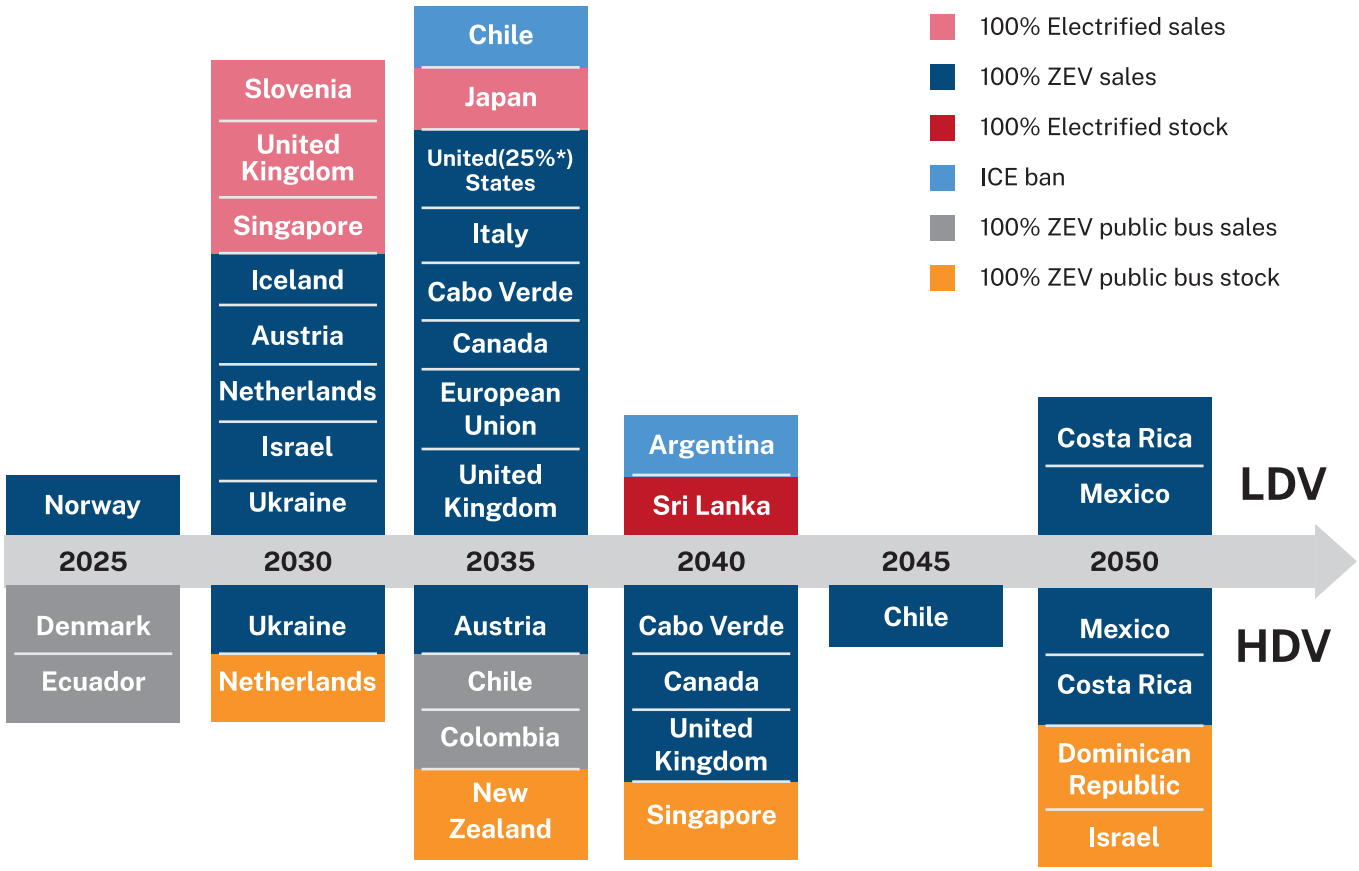
ZEV Commitments Across the World

- In March 2023, the EU adopted new CO2 standards in line with their 'Fit for 55' package, which mandates a 55% reduction in emissions of new cars by 2030 (compared to 2021) and 100% by 2035.
- The new Euro 7 emissions proposed standards for cars, vans, trucks, and buses regulate tailpipe emissions as well as emissions from brakes and tyres, including for EVs.
- The US Environmental Protection Agency has proposed stricter emission standards for light, medium, and heavy-duty vehicles.
- California's Advanced Clean Cars II (ACC II) rule has set a minimum ZEV sales share for passenger cars, ranging from 35% in 2026 to 100% in 2035. This means that in California (and other US states that adopt this rule), any vehicle sold from 2035 onwards must be a zero-emission vehicle (ZEV) or a PHEV.
- The US government has announced that by 2030, at least 50% of all vehicles sold in the country must be ZEVs.
- The UK has announced plans to end the sale of ICE vehicles by 2030, with a full transition to 100% ZEV sales by 2035.
- In Norway, EVs accounted for 79% of new passenger car registrations in 2022. Notably, Norway's electricity generation is almost exclusively from hydropower, making EVs truly a green initiative in Norway.
- Greece has announced that it will only allow the sale of zero-emission cars from 2030.
- Switzerland surpassed its target of 15% electric car sales and reached 25% in 2022. The new target has been set at 50% electric car sales share by 2025.
- Canada has set a goal to achieve a zero-emission sales share of 20% by 2026, 60% by 2030, and 100% by 2035.
- Additionally, many automakers, such as BYD, Jaguar, and Mitsubishi, have voluntarily set electrification targets for their car brands.

Global ZEV Mandates and ICE Bans as per the IEA:

According to an analysis by the IEA, several countries have announced targets to phase out ICE vehicles in the next 20 years:

- The ICE ban will be targeted by countries such as Chile by 2035 and Argentina by 2040.
- 100% electrified sales targets are set by the UK and Singapore by 2030 and Japan by 2035.
- A majority of countries have announced 100% zero-emission targets, such as Norway, which will achieve its goal as early as 2025, Austria, the Netherlands, and Iceland by 2030, and many other countries by 2050.



Source: IEA analysis

*ICE: Internal Combustion Engine
*LDV: Light-Duty Vehicles
*HDV: Heavy-Duty Vehicles
*ZEV: Zero-Emission Vehicles

6. POLICY SUPPORT FOR EVs ACROSS THE WORLD

Global policies supporting EVs typically include fuel economy and pollutant standards,
zero-emission vehicle mandates or bans on ICE vehicles (as covered in the above section), fiscal regimes and taxation policies for fuel and vehicles, and purchase incentives and subsidies.

In 2022, more than 90% of global sales of light-duty EVs and 70% of heavy-duty EVs were covered by EV-related policies.

According to the IEA Global EV Outlook Report 2023, in 2022, more than 90% of global sales of light-duty EVs (which are the most widely available EVs globally) were covered by EV-related policies. There is a growing policy focus on the heavy-duty vehicle segment, which includes freight trucks, heavy freight trucks and buses. In 2022, almost 70% of global heavy-duty EV sales were covered by EV policies. In 2022, 27 countries signed a memorandum and agreed to target 100% zero-emission new truck and bus sales by 2040.

Many countries have prioritised EV policies since as early as the 1990s in Norway, the US in 2009, and China in 2014. Countries are also introducing policies for electric vehicle supply equipment or charging infrastructure, as a lack of proper charging infrastructure can significantly hinder EV adoption.

Many countries, including India, are also considering industrial policy support for domestic battery and EV production by offering manufacturing incentives.

We examine below the policy support and economic planning in the EV sector in India and globally.

India

On a national level, the government has already launched initiatives such as the Faster Adoption of Manufacturing of Electric Vehicles (FAME) scheme, which is in its second phase of implementation, and the Production Linked Incentive Scheme (PLI). The FAME-I scheme ran from 2015 to 2019 and spent a total overlay of Rs. 895 crores. The FAME-II scheme was adopted effective from 1 April 2019 with a budget of Rs. 10,000 crores. FAME II aimed to subsidise 7,090 e-Buses, 5 lakh e-3 Wheelers, 55,000 e-4 Wheeler Passenger Cars (including hybrids) and 10 lakh e-2 Wheelers.

The FAME-II scheme initially provided a subsidy on the purchase of new electric 2-wheelers up to Rs. 15,000 per kWh of the battery, with the maximum subsidy capped at 40%of the cost of the vehicle. Effective from 1 June 2023, the same is now reduced to Rs. 10,000 per kWh, with the maximum subsidy capped at 15%of the cost of the vehicle. The maximum subsidy for e-buses is Rs. 20,000 per kWh.

Subsidies worth Rs. 5,294 crores have been disbursed under the FAME-II scheme until December 2023, which covers the sale of 11,79,669 EVs, including electric 2-wheelers, 3-wheelers, and cars. The current FAME-II scheme will run until 31 March 2024. The government has not yet announced any extension of the FAME-II scheme or a third phase, i.e., the FAME-III scheme. It is also worth noting that the Karnataka government has announced the levy of a 10% lifetime tax on the purchase of high-end electric vehicles – i.e., priced upwards of Rs. 25 lakhs – at the time of registration.

The government has also announced two Production Linked Incentives (PLI) schemes. The first PLI scheme, the automobile production PLI, has a budgetary outlay of Rs. 25,938 crores and offers incentives for manufacturing EVs and components. The second scheme, the Advanced Chemistry Cell (ACC) battery PLI, has a budgetary overlay of Rs. 18,100 crores and covers facilities for 50 GigaWatts of ACC battery manufacturing.

100% Foreign Direct Investment (FDI) is allowed in the EV charging infrastructure sector, which encourages private investment in the Indian market.

In the 2023-24 Union Budget, a budget allocation of Rs. 35,000 crores has been announced for crucial capital investments aimed at achieving energy transition and net-zero targets by 2070. The Government is also supporting Battery Energy Storage Systems, which have a capacity of 4,000 mWh, through viability gap funding. The 2023-24 Budget also extended the customs duty exemption to the import of capital goods and machinery required for the manufacture of lithium-ion cells for EV batteries.

In 2019, the GST on electric vehicles was reduced from 12% to 5%. GST on chargers/ charging stations for EVs was also reduced from 18% to 5%. Further, commercial and private BEVs are given green license plates and are exempted from permit requirements.

The FAME-II scheme also provides financial support for installing public charging stations for EVs, including a revenue-sharing model for providing land at promotional rates, and guidelines which limit the single EV charging tariff to the Average Cost of Supply for solar and non-solar hours until 31 March, 2025.

The government also offers a tax deduction of up to Rs. 1.5 lakh on the interest component of an EV loan.

In addition to the national targets, Indian states are also setting their own targets for EV adoption. A total of 26 out of 29 Indian states have offered demand subsidies on the purchase of new EVs and have also adopted their own EV policies:

- States such as Tamil Nadu, Maharashtra, and Himachal Pradesh have exempted EVs from road tax payments.
- States such as Andhra Pradesh, Karnataka, and Assam have set targets to switch to electric buses for public transport, ambulances, school buses, etc.
- Many states have offered subsidies for setting up charging stations. Maharashtra and Delhi are also focusing on battery-swapping infrastructure.
- Electricity subsidies are also being offered in many states, with Tamil Nadu providing a 100% exemption on electricity tax.
- Goa has set a target for all commercial 2-wheelers to switch to fully electric by 2025.
- Maharashtra has set a target for 10% adoption of BEVs by 2025.
- In Delhi, the incentives for EVs and a simplified policy for setting up charging stations have been a success, with Delhi's EV sales in December 2023 accounting for 19.5% of total vehicle sales.

Additionally, public-private partnerships are being set up to build charging stations across highways. Examples of successful public-private partnerships in India's EV space include Hyundai and Indian Institute of Technology (IIT) Delhi's collaboration on EV technology research, and MG Motor and Tata Power's collaboration to establish a fast-charging network across India's cities.

China

China's growth in the EV sector has been the effect of extensive capital investment, government subsidies, economic planning, and technological innovation. The Chinese Government began as early as 2009 to push the EV sector by announcing subsidies and R&D grants and by encouraging EV manufacturing. In 2012, China outlined a strategy for 'New Energy Vehicles (NEVs)' that focused on EV science and technology development and promotion of charging infrastructure. The Chinese government also began providing subsidies on NEVs, including a 50% reduction in vehicle purchase tax and a 'dual credit' system, which essentially incentivised NEV manufacturers and penalised manufacturers of fossil-fuel-powered vehicles. China is also allowing purchase tax exemptions until the end of 2027 for new energy vehicles.

The 2015 'Made in China 2025' strategy focused on the development of fuel cell and battery vehicles and set a target for 20% EV sales by 2025 – a target that China surpassed in 2022 itself.

China's 14th five-year plan targets an advanced charging infrastructure system by 2025, which will meet the demand for over 20 million EVs. As of August 2022, 65% of the global public EV charging points are in China, according to data by Statista. Further, more than 30 Chinese cities have announced plans to achieve 100% electrified public transit.

With the gradual withdrawal of government subsidies, the Chinese market is slowly transitioning from policy-oriented to market-oriented. Further, Chinese automakers are now entering the European markets, where tariffs on the import of Chinese cars are around 9% (as against 27.5% tariffs levied by the US). China's BYD recently announced plans to open an EV plant in Hungary. In 2023, Chinese EVs represented 8.2% of all EV sales in Europe. With Chinese EV brands increasingly flooding the European markets, the European Commission has launched an investigation into the subsidised Chinese EVs sold in Europe.

Europe

Europe's Clean Vehicles Directive has set targets for public procurement of electric buses.

The Alternative Fuels Infrastructure Regulation (AFIR) requires EU Member States to deploy one fast-charging pool every 60 km along the main European routes by 2025.

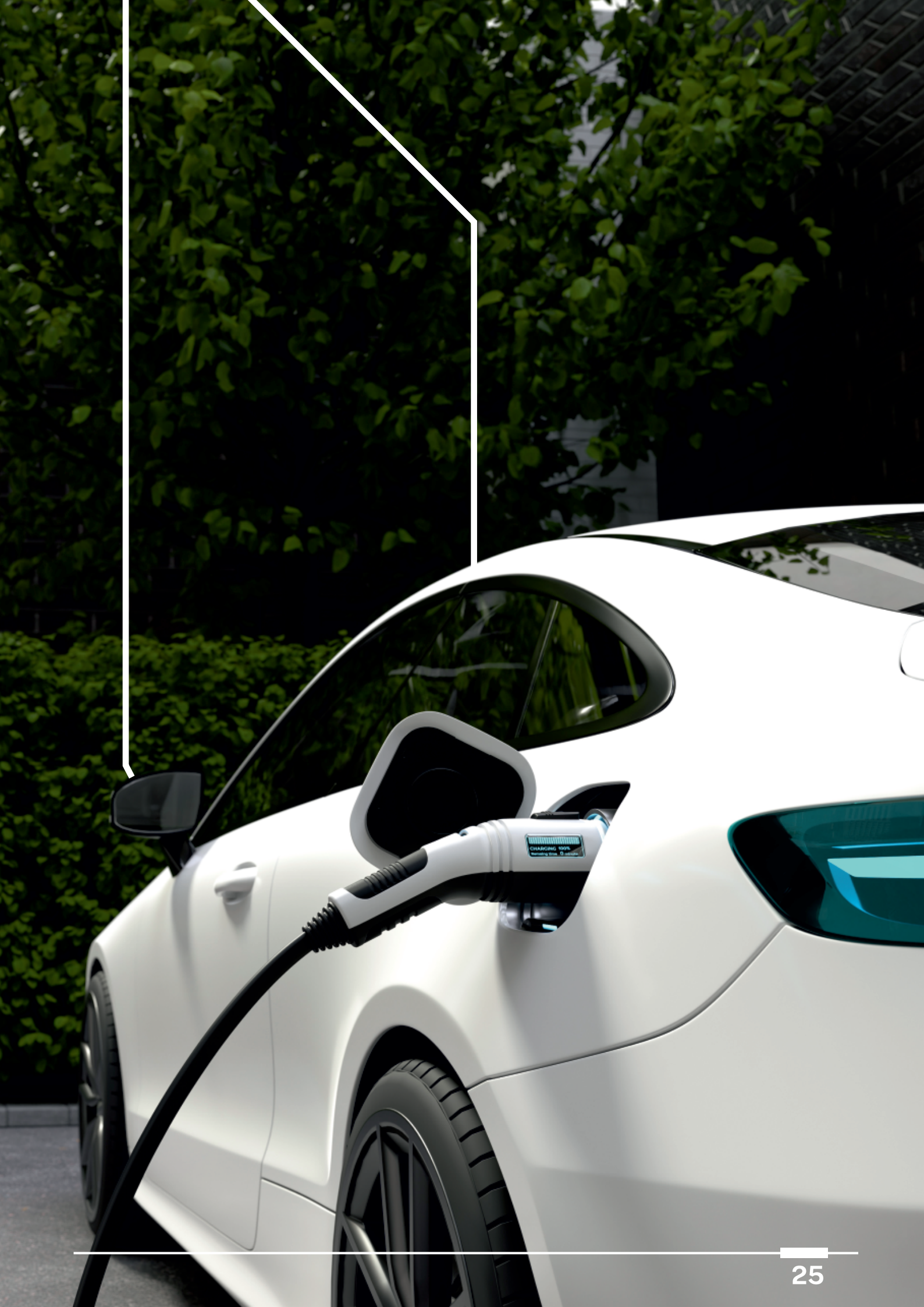
The EU has proposed to target for around 90% of the EU's annual battery demand to be met by EU battery manufacturers, with a manufacturing capacity of at least 550 GWh in 2030.

Germany, which is Europe's largest EV segment, has approved a plan to spend EUR 6.3 billion over 3 years to rapidly expand the number of EV charging stations.

US

The US Inflation Reduction Act (IRA) incentivises the strengthening of domestic supply chains for EVs and batteries in the form of clean vehicle tax credits. According to the IEA 2023 report, between August 2022 and March 2023, American EV and battery makers announced cumulative post-IRA investments of at least USD 52 billion, of which 50% is for battery manufacturing and 20% each for battery components and EV manufacturing.

The US has also allocated USD 5 billion in total funding towards EV charging, as well as USD 2.5 billion in competitive grants.


CHARGING 100%

7. EV ECOSYSTEMS IN INDIA AND AROUND THE WORLD

Global EVs Ecosystem and Charging Infrastructure

There are three levels of EV charging: Level 1, Level 2, and Level 3. Level 1 is the slowest way to charge an EV and only delivers a maximum of 2.3 kW. Level 2 charging stations deliver alternating current (AC) and deliver a power output between 3.4 kW to 22 kW. The majority of public chargers are Level 2 chargers. Level 3 is a fast charger that delivers direct current (DC). Generally, Level 3 chargers can charge a vehicle in minutes as compared to hours taken by Level 2 chargers or days for Level 1 chargers.

Over 1 million new charging points were installed globally in 2023, according to a report by Marketsandmarkets. As of August 2022, 65% of the global public EV charging points were in China, according to data by Statista.

According to the IEA Global Outlook 2023 Report, in 2022, there were 2.7 million public charging points globally, of which over 450,000 were in Europe. Fast chargers' deployment in Europe grew by over 55% in 2022 in Europe and reached almost 70,000 units. The number of fast chargers increased by 330,000 in 2022, of which 90% growth was in China. The US installed 6,300 fast chargers in 2022, about 75% of which were Tesla Superchargers. The Swiss company Morand has developed a fast charger that can charge EVs to 80% in 72 seconds. However, this charger is only suited to small-range cars.

The global average in 2022 was about 10 EVs per charger, as per IEA's analysis. Countries such as China, Korea and the Netherlands maintain less than ten EVs per charger. In the US, the ratio of EVs per charger is 24, and more than 30 in Norway

EV Supply Chain

China leads the entire downstream supply chain for key EV components, particularly lithium-ion batteries and rare earth elements, which have become indispensable for EV manufacturing. According to a report by BloombergNEF, global lithium-ion manufacturing capacity has increased 31% since 2022.

A report by Morgan Stanley states that 90% of the EV battery supply chain relies on China. In 2022, China, South Korea, and Japan together held over 92% share of the global market in battery manufacturing. In 2022, China's production quota of rare earths accounted for 70% of global production, according to Statista.

Recent supply chain disruptions are largely the effect of macroeconomic factors such as the COVID-19 pandemic, the global semiconductor shortage, the Ukraine-Russia conflict, and high prices of critical minerals. In order to reduce reliance on China and strengthen the local EV value chain, the US, Europe, and many other countries are implementing policies to subsidise domestic manufacturing for sectors such as EVs and renewable energy.

Indonesia has significant raw mineral resources and is the world's largest nickel miner, with a 48% share. Behind China, Australia is the largest producer of rare-earth elements used in high-tech manufacturing. Iran, in 2023, claimed to have identified lithium reserves amounting to 8.5 million tonnes, or the second largest reserve in the world.

In February 2023, India announced its first inferred lithium deposits of 5.9 million tonnes, which could potentially be a game-changer for India's supply chain and for global cell manufacturing.

India's Charging Ecosystem

The Indian-compatible charging specifications for EVs are as follows:

S. No	Charging Station	Voltage (V)	Power	Type of Vehicle	Type of compatible charger
1	Level 1 (AC)	240	<=3.5 kW	4-wheeler, 3-wheeler, 2-wheeler	Type 1, Bharat AC-001
2	Level 1 (DC)	>=48	<=15 kW	4-wheeler, 3-wheeler, 2-wheeler	Bharat DC-001
3	Level 2 (AC)	380-400	<=22 kW	4-wheeler, 3-wheeler, 2-wheeler	Type 1, Type 2, GB/T, Bharat AC-001
4	Level 3 (AC)	200-1000	22 to 4.3 kW	4-wheeler	Type 2
5	Level 3 (DC)	200-1000	Up to 400 kW	4-wheeler	Type 2, CHAdeMO, CCS1, CCS2

India's first EV charging plaza was set up in June 2020. As of 2 February 2024, India has 12,146 operational public charging stations, as per information provided by the Ministry of Power.

The number of charging stations state-wise as of 2 February 2024 are as follows:

S. No.	State Name	No. of Operational Public Charging Stations
1	Andaman & Nicobar	3
2	Andhra Pradesh	327
3	Arunachal Pradesh	9
4	Assam	86
5	Bihar	124
6	Chandigarh	12
7	Chhattisgarh	149
8	D&D and DNH	1
9	Delhi	1886
10	Goa	113
11	Gujarat	476
12	Haryana	377
13	Himachal Pradesh	44
14	Jammu & Kashmir	47
15	Jharkhand	135
16	Karnataka	1041
17	Kerala	852
18	Lakshadweep	1
19	Madhya Pradesh	341
20	Maharashtra	3079
21	Manipur	17
22	Meghalaya	21
23	Nagaland	6
24	Odisha	198
25	Pondicherry	23
26	Punjab	158
27	Rajasthan	500
28	Sikkim	2
29	Tamil Nadu	643
30	Telangana	481
31	Tripura	18
32	Uttar Pradesh	582
33	Uttarakhand	76
34	West Bengal	318
Total		**12,146**

As shown above, Maharashtra ranks at the top with 3079 operational charging stations, followed by Delhi with 1866.

According to JMK Research, Tata, Charge+Zone, and Ather are the top 3 players in the fast-charging category, while Bolt and EVRE are the top 2 players in the slow-charging category.

The government aims to set up 50,000 EV charging stations by 2030. As per the 2022 guidelines by the Ministry of Power, at least one EV charging station shall be available on a grid of 3 km x 3 km. Further, one EV charging station is to be set up every 25 km on both sides of highways and roads.

The Ministry of Heavy Industries had sanctioned 520 charging stations under FAME-I. An additional 2,877 charging stations in 68 cities and 1,576 charging stations across 9 expressways and 16 highways are also sanctioned under FAME-II.

The Ministry has also sanctioned Oil Marketing Companies (OMCs) to establish 22,000 EV public charging stations.

India requires at least 1.32 million charging stations by 2030, considering annual sales of 106 million EVs every year and assuming a requirement of 1 charger per every 40 EVs, according to a report by the Confederation of Indian Industry (CII). By September 2023, India had approximately one EV charging station for 135 EVs (as compared to the global average of one charger for 20 EVs). However, these charging stations are unevenly distributed across the country. Case in point – by mid-2023, Uttar Pradesh had 4.5 lakh EVs but only 406 charging stations, i.e., there was one charging station for every 1,103 EVs in the state.

By September 2023, India had approximately one EV charging station for 135 EVs (as compared to the global average of one charger for 20 EVs). However, these charging stations are unevenly distributed across the country. Case in point – by mid-2023, Uttar Pradesh has 4.5 lakh EVs but only 406 charging stations, i.e., there was one charging station for every 1,103 EVs in the state.

Battery Recycling

By September 2023, India had approximately one EV charging station for 135 EVs (as compared to the global average of one charger for 20 EVs). However, these charging stations are unevenly distributed across the country. Case in point – by mid-2023, Uttar Pradesh had 4.5 lakh EVs but only 406 charging stations, i.e., there was one charging station for every 1,103 EVs in the state.In 2022, India issued Battery Waste Management Rules, which aim at recycling or refurbishing batteries, including EV batteries. India targets to increase the recycled content of EV batteries to 20% by 2030, including for imported products. In India, companies like Tata Chemicals and Attero have established businesses in lithium-ion battery recycling.

Battery-Swapping

There is an increased focus on battery-swapping of electric 2 and 3-wheelers in India. In 2022, Niti Aayog proposed the new battery-as-a-service (BaaS) model in India's ecosystem. There are currently over 10 different companies in the Indian market providing battery-swapping services. Gogoro, a Chinese company, has formed a partnership with India's Zypp Electric to deploy battery-swapping stations and electric 2-wheelers for business-to-business last-mile delivery operations in Delhi. According to an analysis by the International Council on Clean Transportation (ICCT), battery-swapping for electric 2-wheelers in taxi services (e.g. bike taxis) offers the most competitive Total Cost of Ownership (TCO) compared to point-charging BEVs or ICE 2-wheelers. In 2019, Ashok Leyland set up the first electric bus battery-swapping station in India.

Retrofitting

A report by Primus Partners and ETB has suggested that the Indian government could consider offering incentives to retrofit old vehicles into electric ones instead of scrapping them. Presently, in India, commercial vehicles over 15 years and passenger vehicles over 20 years of age are required to pay increased re-registration fees or else scrap the vehicle. Retrofitting policy could help India reach its electrification targets in the road transport sector.

The central government has released AIS 123 regulations for the certification of retrofitment kits and retrofitted vehicles. The Delhi and Andhra Pradesh governments are focusing more on retrofitting, which will allow customers to convert old petrol/diesel/CNG cars to EVs instead of scrapping them, provided the necessary approvals are granted by the authorities. At present, there are a handful of start-ups in India that offer EV retrofitting kits.

However, the retrofitting process is costly, with each kit priced at approximately Rs. 4-5 lakh, even for entry-level cars. Further, there are challenges, such as high (18%) rate of GST on auto components and the difficulty in acquiring loans for the conversion of passenger vehicles to EVs.

As of 2023, the global retrofit vehicle market is estimated at USD 65.94 billion and projected to reach USD 125.37 billion by 2032 with a Compound Annual Growth Rate (CAGR) of 7.40%.

8. CHALLENGES FOR INDIA'S EV INDUSTRY AND POTENTIAL SOLUTIONS

India's EV market is predicted to grow at a Compound Annual Growth Rate (CAGR) of 49% between 2022 and 2030, as per the Economic Survey 2023, reaching 10 million annual sales by 2030. The Indian EV industry is also projected to create around 50 million direct and indirect jobs by 2030. India has set a target to electrify 70% of commercial cars, 30% of private cars, 40% of buses, and 80% of 2-wheelers and 3-wheelers by 2030.

However, despite the uptake in EV adoption, there are several challenges which, if not overcome effectively, may slow down the achievement of India's zero-emission targets. Some of these challenges have already been covered in the earlier sections, such as a weak EV supply chain and high import costs leading to high EV prices. We will cover those points and others in detail below.

Range Anxiety

Range anxiety is one of the main concerns among potential buyers of EVs. As compared to ICE vehicles, EVs are not yet suited for long-range driving, particularly because charging infrastructure is not widely available across India's highways and roads. Although high-end EVs with larger batteries offer up to 700 km range on a single charge, these cars are more expensive than the cheaper EV models and significantly more expensive than their ICE counterparts.

Battery Life

While EV manufacturers currently provide a warranty on batteries of 5 to 8 years, there are concerns regarding battery life and replacement cycle, especially considering the high cost of new batteries. Because EV technology is still new, The exact replacement cycle of EV batteries is not known with certainty. It is estimated that the average cost to replace the battery in a Tata Nexon EV is between Rs. 5 to 7 lakhs; however, the automaker provides a warranty of 8 years. For an electric 2-wheeler, the average cost to replace the battery is around Rs. 50,000.

High TCO

As mentioned above, the Total Cost of Ownership (TCO) for EVs in India is still high. Even though the running and maintenance costs of EVs are lower than ICE vehicles, the upfront prices are still high. Although a tax benefit is offered on the interest component of an EV loan, the cost of insurance and repairs is higher than ICE vehicles. Further, the buyer must consider additional costs such as home/solar-powered charging stations, electricity costs, etc. In some countries, such as China, EV prices are at par or cheaper than ICE vehicles even at the point of purchase.

Limited Charging Infrastructure

As detailed in the earlier sections, India needs to accelerate the installation of charging infrastructure across the country. Most of India's 9,000 public charging stations are located in metro cities. Range anxiety has highlighted the need for better charging infrastructure in rural areas as well. India also needs to implement smart charging infrastructure by incorporating embedded systems for real-time monitoring and optimisation.

The government is also attempting to integrate renewable energy sources into the EV charging infrastructure. The Ministry of Power's 2021 guidelines include a mandate for installing solar panels at public EV charging stations with a capacity of at least 10% of the total charging station capacity.

Renewable Energy Charging

Using renewable energy sources to charge EVs can make the charging infrastructure cheaper and sustainable as it reduces the dependence on fossil fuels. Renewable energy sources will also help in reducing power cuts. In 2022-23, renewable energy sources made up 40% of total energy generation in India, with the majority contributed by solar and wind energy, as per data by the Ministry of New and Renewable Energy.

Outdated Power Grids

As per a Brookings report, the anticipated surge in EVs by 2030 is expected to place significant strain on India's power grid, potentially leading to power outages. The Government is looking into updating its power grid by considering smart grids, which integrate information and communication technology by allowing two-way transmission of energy and information.

Lack of Awareness Among Consumers

India's successful Go-Electric campaign, along with the subsidies and incentives provided by the Government, has helped bring attention to the EV sector, as evidenced by the growth in recent years. However, there are still concerns among consumers and even some misconceptions regarding EVs for which consumer awareness campaigns are necessary.

For example, rural areas have not seen a major uptake in EV adoption yet. On the other hand, many Indian villages are self-sufficient in terms of electricity generation, thus making EVs the perfect and certainly the greener choice of road transport.

Software-related Challenges

EVs still face certain software incompatibilities and cybersecurity issues – an area of technology with a promising solution in the coming years. Buyers may also view features such as AI-integrated software or over-the-air (OTA) updates in vehicle operations as an inconvenience. These challenges also present themselves in electric 2-wheelers, 3-wheelers, and heavy-duty cargo transport EVs because of their design. As a solution, there must be increased focus on new EV OS supporting advanced safety features, load management, routing capabilities, and advanced driver assistance systems (ADAS).

Financing

With rising consumer demand and high pricing for EVs comes the need for effective financing solutions. 77% of all vehicles in India are financed through banks and non-banking financial corporations (NBFCs), as well as private and institutional guarantors.

There is, however, a perceived risk accompanied by high interest rates on EV loans, mainly due to a lack of resale market and charging infrastructure, as well as range anxiety among users.

The insurance premium is also higher on EVs as compared to ICE vehicles. To address these issues, the Delhi and Kerala governments are providing interest subventions (5% for 3-wheelers in Delhi and 3% subvention in Kerala for all EV loans).

A CII report has recommended a 'first loss fund' mechanism to support increased lending for EV purchases. The Reserve Bank of India (RBI) is expected to put EV financing under priority lending, which will potentially increase the proportion of loans available for this sector.

Potential Remedies

A lot of the challenges faced by India's EV industry may be solved if India's new policies are successful. These policies focus on domestic manufacturing of EVs and auto components and accelerating charging infrastructure throughout urban and rural areas, highways, and roads. Further, as discussed in the earlier sections, India heavily imports lithium-ion batteries at a high cost. If India can rely on its new-found lithium reserves, it will be a game-changer for manufacturing EV batteries indigenously, which will bring down battery pack prices and lead to a cost-effective supply chain for India, thus driving up EV adoption faster.

9. INDUSTRIES AFFECTED BY THE EV BOOM

With EVs poised to take over the global road transport sector, the world is experiencing a shift. The obvious industries to be affected include the auto industry, which will witness a shift in demand for traditional cars and auto parts, along with a reskilling of labour to manage the rising demand for EVs. The EV sector will also impact the demand for oil and critical minerals required for manufacturing EV batteries (covered below), as well as the infrastructure sector for building charging stations and industries connected to EV operating software such as generative AI, 5G technology, etc.

Oil and Gas Industry

At the top of this displacement is the world's oil demand. Presently, the road transport sector accounts for more than 45% of the global oil demand – a scenario predicted to change by 2030, according to the IEA. The IEA estimates that by 2030, EVs will have erased around 5 million barrels per day of world oil demand and will boost electricity demand by 165 tWh.

Metals and Mining

The increase in EV battery demand drives the demand for critical materials. According to the IEA 2023 report, in 2022, about 60% of lithium, 30% of cobalt and 10% of nickel demand was for EV batteries. As per Goldman Sachs, the demand for EV battery metals will increase tenfold by 2025. The rising demand for minerals is driving innovations in mining practices and sustainable resource extraction techniques.

Solar PV Manufacturing

Renewable power capacity additions are of paramount importance as demand for EVs grows and nations target net-zero by 2050. Utility-scale solar photovoltaics (PV) is the least costly option for new electricity generation in a significant majority of countries worldwide. Solar PV and wind account for a record 96% of renewable power capacity additions in the world. Solar PV plants dominate the renewables power purchase agreements, with a share of almost 70% in 2022, as per the IEA.

According to data released by the Ministry of New and Renewable Energy (MNRE), till December 2023, India's renewable energy installation capacity reached 133.89 GW, of which solar energy contributes a 55% share, followed by wind energy (33%), BioPower (8%), and Small Hydro (4%). India has targeted the convergence of solar energy and electric vehicles, with many companies (including Tata Power Solar) and start-ups setting up solar-powered EV charging stations. Solar rooftop EV chargers are also becoming commercially available. The Ministry of Power's 2021 guidelines include a mandate for installing solar panels at public EV charging stations with a capacity of at least 10% of the total charging station capacity.


eco

10. INNOVATIONS IN THE EV SPACE AND POTENTIAL OUTLOOK

2024 is poised to take the EV landscape further than ever imagined. With EVs revolutionising the global road transport sector, below are outlined some new innovations that are steering this ship.

Battery Technology Innovations

Presently, the majority of EV batteries are lithium-ion batteries. The demand for lithium-ion batteries increased by about 65% in 2022 as compared to 2021 as a result of growth in passenger EV sales. There are safety risks associated with lithium-ion batteries, as well as lower energy density and shorter life span. The EV battery makes up around 40% of the manufacturing cost of an EV in India. Innovation in the EV battery space is, therefore, the need of the hour.

According to the IEA 2023 report, lithium nickel manganese cobalt oxide represented a market share of 60%, followed by lithium iron phosphate (LFP) with a share of just under 30%, and nickel cobalt aluminium oxide (NCA) with a share of about 8%. Current innovations in batteries also include solid-state batteries, lithium-sulphur batteries, and metal-air batteries.

Solid-state batteries use solid electrolytes over liquid or gel, which provide better safety, performance, durability, and higher energy storage. Estimates also suggest that these batteries can store more energy with fewer materials, reducing an EV's carbon footprint by 24%.

Chinese manufacturer Nio is planning to launch an EV with a solid-state battery of 150kWh capacity, which is expected to be 40% denser than lithium-ion batteries. MIT has created a new method for stabilising electrode interfaces and is working with Toyota to build all-state-solid batteries.

Metal-air Batteries use metals such as zinc or aluminium, which reduce the total weight and improve the efficiency of an EV. Indian Oil Corporation and Phinergy, an Israeli battery developer, are manufacturing lightweight metal-air batteries.

Lithium-sulphur batteries are lightweight and offer greater energy storage at reduced costs due to the abundant availability of sulphur. A lithium-sulphur battery could potentially double the driving range of an EV and may also reduce the weight of the battery pack by half. However, lithium-sulphur batteries are still not yet available commercially as they are majorly still in the research phase.

A US-based start-up, QuantumScape, has developed a semi-solid state cell battery which could boost an EV's driving range by 14% to 43%.

Estimates suggest that 100 million EV batteries will need to be scrapped in the next decade. In response, battery recycling technologies are being explored globally, which can extend battery lifespans and reduce operational costs.

Charging Innovations

Most of the new EV chargers being set up globally are Level 3 or DC fast chargers. Many automakers are offering fast chargers that will charge EVs within minutes, and research is ongoing for new ultra-charging technologies. Some other new technologies in EV charging are as follows:

Bi-directional Charging

Existing EV charging technology sends energy in one direction, i.e., from a power source to a car's battery. Bidirectional charging allows the vehicle to send that energy back to the grid (Vehicle-To-Grid - V2G), to power homes (Vehicle-To-Home - V2H), to power appliances or tools (Vehicle-To-Load - V2L), or to send energy to other cars (Vehicle-To-Vehicle - V2V).

With a bidirectional charger, the converter transforms the car's Direct Current (DC) energy back into Alternating Current (AC) electricity and sends it to another recipient. Such a conversion process requires smart-charging technology.

With V2G, the battery capacity is estimated to be utilised up to 10 times more efficiently than regular smart charging, according to Virta Global. V2G allows customers to save on electricity costs by selling unused energy back to the grid for redistribution. Certain EV models which allow V2V are already commercially available in the market, such as Nissan's Leafs and e-NV200 and Mitsubishi's Outlander PHEV and iMiev models.

The V2G market is projected to grow to over EUR 5 billion by 2024.

Electrified Roads

Electrified roads use overhead power lines to power larger EVs (other than passenger EVs). The world's first electrified road has been operating in Sweden since 2018. The road recharges the batteries of cars and trucks while they drive along it by transferring electricity from two tracks of rail in the road via a movable arm attached to the bottom of a car or truck. Sweden is now building the world's first electrified highway, which is expected to be completed by 2025. The highway is on European route E20 connects logistic hubs between Hallsberg and Örebro, and will allow electric cars and trucks to recharge while driving.

The US has also unveiled its first wireless charging road in Detroit in 2023. The road spans a quarter mile and has under-road coil segments that wireless charge electric vehicles while driving.

Wireless Charging

The UK announced a wireless charging trial in Nottingham in 2022. Five wireless charging pads are being installed at the Trent Street rank, and 9 council-owned electric taxis are being fitted with wireless charging hardware in the UK. If successful, this technology, which allows multiple EVs to wirelessly recharge at the same time, could be installed globally.

Innovations in EV OS

Software-integrated vehicles are increasingly taking over the centre of the future EV space. The Operating Software (OS) is responsible for almost all aspects of the EV's functionality. The better the OS, the better it can be managed and utilised in its lifetime. An OS also oversees functions such as regenerative braking, which capture and convert kinetic energy back into stored electricity, extending the driving range.

Many automakers are integrating their EV models with AI, machine learning, and Internet of Things (IoT) sensors. Tesla's Autopilot uses AI to provide features such as adaptive cruise control, self-parking, etc.

There is also a growing need for advanced driver assistance systems (ADAS) to be integrated into EVs, especially for Indian 2-wheelers. ADAS includes automated technologies such as sensors and cameras to assist drivers with the safe operation of a vehicle.

Currently, ADAS OS exist for 4-wheelers, but the same has not yet been implemented for 2-wheelers.

Continental Automotive India is working on a 2-wheeler ADAS system for Indian original equipment manufacturers (OEMs).

With new innovations taking place at a tremendous pace in the EV market, the collective goal of net zero via the switch to electric vehicles seems promising. The field is led by technological and engineering innovations, and EVs will soon become a perfect blend of software and hardware. We can predict a shift to battery electric vehicles (BEVs) for inter-city mobility and long-range EVs or hydrogen fuel cell EVs for long-distance travel. The future outlook of EVs in India depends on how fast the relevant technologies can be developed commercially, such as hydrogen fuel cell EVs, cheaper lithium-ion batteries and lithium-sulphur batteries, and charging innovations such as wireless charging roads, bi-directional charging, and more.

KIRTANE & PANDIT

Pune

5th Floor, Wing A, Gopal House, S.No. 127/1B/11,
Plot A1, Kothrud,
Pune – 411 038, India
Contact no : +91 20 67295100 / 25433104
E -mail : kpca@kirtanepandit.com

Mumbai

601, 6th Floor, Earth Vintage, Senapati Bapat Marg, Dadar West,
Mumbai- 400 028, India
Contact no : 022 69328846 / 47 / 48
E -mail : kpcamumbai@kirtanepandit.com

New Delhi

272, Rajdhani Enclave, Pitampura,
Delhi-110034, India
Contact no : +91-9911814171
E -mail : kpcadelhi@kirtanepandit.com

Bengaluru

No. 63/1, I Floor, Makam Plaza, III Main Road, 18th Cross, Malleshwaram, Bengaluru – 560 055, India
Contact no : 080 23443548 / 23461455
E -mail : kpcabengaluru@kirtanepandit.com

Nashik

Flat No. A- 102, Malpani Saffron, Near Hotel Express, Inn, Pathardi Phata,
Nashik -422010, India
Contact no : +91 253 2386644
E - mail : kpcanashik@kirtanepandit.com

Hyderabad

401 to 405, 4th Floor, Sanatana Eternal,
3-6-108/1, Liberty Road, Himayatnagar,
Hyderabad - 500 029, India
Contact no : +91 99127 41089 / 94400 55917 / 98480 44743 / 98480 46106
E -mail : kpcahyderabad@kirtanepandit.com

Chennai

No. 128, Old No. 34, Unit No. 1, 6th Floor,
Crown Court, Cathedral Road Gopalapuram
Chennai 600086
Contact no : 044 477928514
E -mail : kpcachennai@kirtanepandit.com

Follow Us On:

kpca@kirtanepandit.com
www.kirtanepandit.com

Authored by
The Knowledge Management Team

Co-Authored by
CA Madhura Thatte