KPMG

Confederation of Indian Industry

Technology at the forefront of electric vehicles

April 2023

Contents

Foreword

Electric Vehicles are the apex of contemporary transportation. It is a revolutionary and path breaking technology which is transforming the very fabric of our society. The state-of-the-art technology, EVs represent the ultimate driving experience. Thus, offering a sustainable and efficient alternative to traditional internal combustion engines, reducing emissions, and promoting a cleaner environment.

Delhi government has always been very aggressive regarding EVs since it is crucial for reduction in air pollution and improving the city's overall sustainability. Its efforts are also reflective in its policies which is evident from the mandate of all new government vehicles to be electric with a target to have 25% of all vehicles in the city run on electricity by 2024. In the year 2022, under the directives of The Hon'ble Supreme Court of India; Transport Department of Government of National Capital Territory of Delhi also started the work on de-registration of all diesel vehicles more than 10 years old and all petrol vehicles more than 15 years old. The initiative was aimed towards promotion of green transportation towards a sustainable future. Delhi has always been the pioneer in space of EV since it is the first state in India to incentivize e-cycles, further promoting clean transportation. The state continues to take bold steps towards a sustainable future with its leadership in the electric vehicle (EV) sector and has established itself as the first one in the country to come up with a step-by-step guide to help employers adopt workplace charging of EVs.

The Confederation of Indian Industry (CII), Delhi has been working closely with various stakeholders including government, industry, start-ups, academia to develop a robust eco-system for EV in the state as well as promotion of adoption of electric vehicles (EVs) in India. CII Delhi also played an instrumental role in drafting policies, sharing recommendations for the adoption of EVs. CII Delhi is actively promoting awareness of the advantages of EVs by organising informative workshops, conferences, and conducting surveys. With a steadfast commitment to the EV sector, CII Delhi is driving the necessary changes that will serve as a catalyst for the success of the EV industry in India. As the EV revolution gains momentum in India, Delhi's initiatives are expected to inspire other states to follow suit, creating a comprehensive and sustainable EV ecosystem across the nation.

India can achieve its vision of a sustainable and eco-friendly future fuelled by electric vehicles with the persistent backing of the government, industry, and the community.

Puneet Kaura
Chairman - CII Delhi State &
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Foreword

Climate change has become one of the most pressing issues across nations. While there have been many factors exacerbating the climate concerns, one of the major contributors to it is the transport sector. The role of transport decarbonisation in global climate action is garnering attention, as governments try to draft supportive policies towards the adoption of sustainable practices and achieve a carbon neutral status. Numerous initiatives are being taken to support the growth of electric vehicles (EVs) globally, resulting in a 39.1 per cent y-o-y growth in the units sold in 2022.

For India as well, 2022 was a prominent year for EV sales, crossing the one million threshold. In the current scenario, two wheelers and three wheelers have been driving most EV sales, as these categories fulfill most of the requirements for switching to an electric fleet. High route predictability, economic viability and ability to use private chargers are some of the factors pushing adoption within these segments. Additionally, the B2B segment has been driving the sales of electric four-wheeler and buses. Favourable government policies, robust charging infrastructure and focus on decreasing the cost of ownership could further lead to higher penetration into segments, including buses and LCVs.

With the advent of EVs, a lot of technological transformation has also come into play. For instance, the engine from traditional ICEs is replaced by a battery, accompanied by a Battery Management System (BMS), while the transmission has been replaced by motor and a controller. As technology takes the centerstage, new suppliers of crucial and new components could enter this domain, leveraging new business opportunities this space has to offer. Accordingly, a large portion of the automotive ecosystem will need to be rebuilt and customised to meet the future requirements. While there has been a lot of focus on digitisation, there have also been continuous efforts towards alternative battery technology. Next-generation technologies, such as advanced chemistry cells are being explored for the development of batteries using alternative raw materials that are abundant in nature, are cost effective, and are impacted less by market volatility. All such technologies are being continuously tested and are either in the concept, prototype or demonstration stages. While ACCs are being developed globally, there is also a push towards localising the production of Li-ion batteries in India. The government of India is therefore undertaking measures towards local manufacturing and has rolled out the Production Linked Incentive (PLI) Scheme, incentivising the manufacturers for lithium-ion battery production. Advanced telematics and IoT enablement, virtual diagnostics, application-based monitoring, and OTA updates are also being developed in parallel, as part of innovative digital solutions.

Technology is also permeating into the support infrastructure and wider ecosystem as well. Traditional companies have been reluctant to enter the EV financing market, owing to the fears around technology obsolescence, customer defaults, manufacturer bankruptcy and low resale value, in addition to higher interest rates and limited financing options. Consequently, small NBFCs and fintech start-ups are planning to leverage their first-mover advantage in the EV lending space. While incumbents are still evaluating their entry into EV financing, these players are infusing technology into the financing space with digital payments, vehicle maintenance, tracking and utilisation of data to assess risks, among others. Technological innovation is eminent in charging solutions as well, enabling faster charging technologies, integration with digital payment platforms, wireless charging and smart features. Artificial intelligence (AI), Internet of Things (IoT), and other cutting-edge technologies are also helping enhance utilisation while maximising the effectiveness and performance of products. In addition to this, end of life solutions are also being assessed to make the best use of the batteries, including battery recycling and second life application of batteries, alongside battery waste management.

While newer innovations are flourishing all across the EV landscape, a lot of new business opportunities and models have also emanated through EV adoption. The development of charging infrastructure is transitioning away from standalone charging stations to fragmented destination-based chargers. This is enabling ease of access and financial feasibility. Another model gaining traction is Battery as a Service (BaaS), which aims to reduce charging wait times along with high upfront cost of EVs. Battery leasing is another area that is being explored by companies, offering better flexibility to consumers when it comes to eliminating the cost disadvantages of purchasing an EV that comes with a high investment and other factors causing apprehensions around an EV purchase. Notably, new business opportunities are stemming as companies innovate throughout the EV value chain.

Technology is playing a major role in driving the momentum in the EV domain. Many of these technologies are going to become standard offerings in the future and addition of newer features and solutions is going to be a continual process. This is where start-ups are going to gain an edge, and will play a major role in offering a technical niche, hence, outperforming the traditional players in this space. While EVs have become a part of strategic action plan for some of the traditional players recently, the start-ups have capitalised well on the growing opportunities EVs have to offer. Therefore, it would be imperative for industry peers to develop the right technological capabilities and drive faster digital adoption to utilise the full potential of the growing EV industry. This is a fast-paced ecosystem and would demand continuous innovation from both existing peers and new entrants.

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Partner, Automotive and Lead
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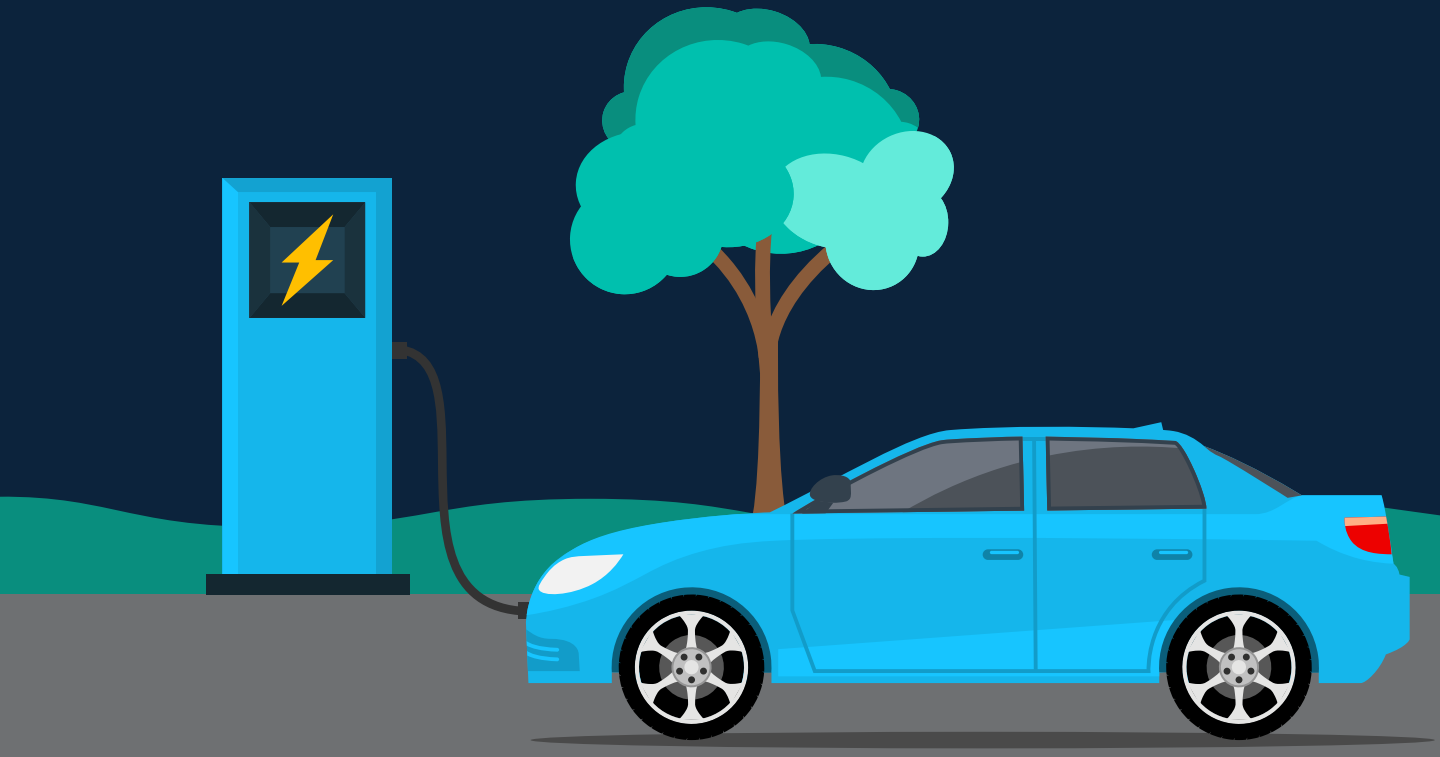
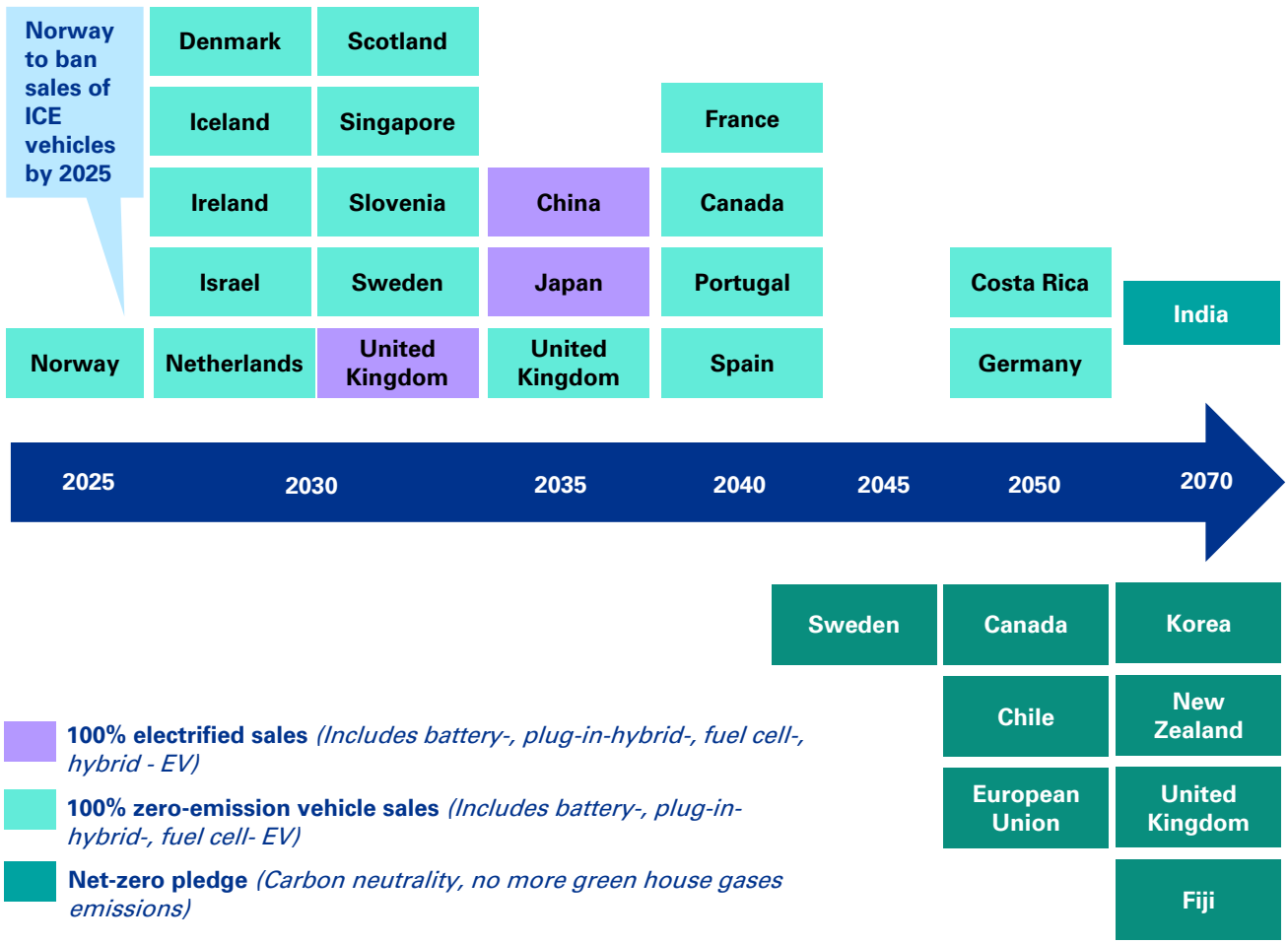


1 Global electric vehicle (EV) revolution

Climate change has become a critical issue across the globe, causing a serious threat to the entire ecosystem, biodiversity, and health. The year 2022 was the sixth warmest year since global records began in 1880[1]. Between 2030 and 2050, an additional 250,000 deaths per year are anticipated as a result of climate change. By 2030, it is anticipated that it could cost around ~INR15,000 crore to INR35,000 crore* annually towards the health damage from climate prone diseases[2].

Road transport has been a major contributor to climate change, accounting for 16 per cent of global emissions[3]. The role of transport decarbonisation in global climate action is gaining attention, as governments all over the world are adopting supportive policies to phase out Internal Combustion Engines (ICE) and push for EVs, which have zero tailpipe emission.

Fig 1.1 Pledges for net-zero emissions[4]

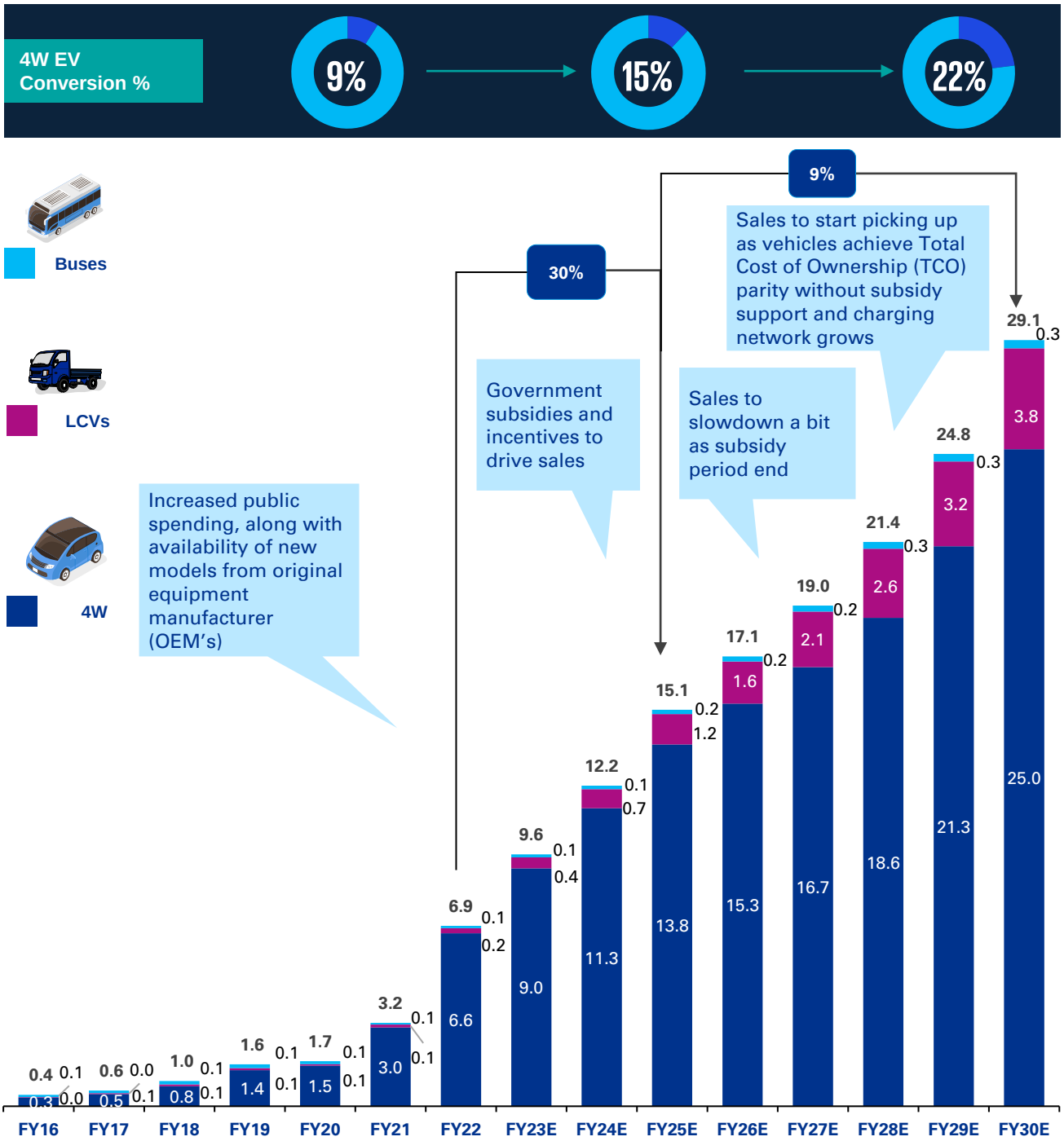


Note: *The currency has been converted as per currency conversion rate of 1USD = 82.23INR, as of 29 March 2023. This rate has been followed across the document wherever the values have been converted from USD to INR, and is indicated with an asterisk (*)

1. Climate Change: Global Temperature, Climate.gov, 18 January 2023
2. Climate change, WHO
3. Electric Vehicles Tracking report, IEA, September 2022
4. IEA Global EV Outlook 2021

Accelerated by the initiatives undertaken by the countries, there has been a significant growth in the sale of EVs globally, with 2022 witnessing a 39.1 per cent y-o-y growth in units sold. In 2022, 9 per cent of all 4-wheeler vehicles (4W) were EVs and this number is expected to reach 22 per cent by 2030.

Fig 1.2 Global annual EV sales (million units, not including 2-Wheeler (2W) & 3-Wheeler (3W))[1]



Note: electric 2W sales not included in the global estimation of EV sales as only China and India dominate the global 2W markets

1. IEA Global EV Outlook 2021

2 Why transition to EV matters to India?

In line with the global scenario, India too has faced significant challenges related to carbon emissions. India is the third-largest emitter of carbon in the world, with carbon emissions increasing by 6 per cent y-o-y in 2022[1].

39 out of 50
World's most polluted cities in India in 2022[2]

1.6 million
Deaths in India linked to air pollution in 2019[3]

5.4 per cent of GDP
The cost of serious health issue from air pollution in 2020[4]

A key solution to achieving net zero objectives is to decarbonise the transport industry, a primary emitter of greenhouse gases. Along with the concerns around climate change, the use of ICE vehicles has also increased the country's dependence on fossil fuels. Considering that 85 per cent of India's energy needs are imported, the transition away from ICE can be advantageous for the country's economy as well.

6.8 per cent
India's contribution to global carbon emissions from burning fossil fuels[5]

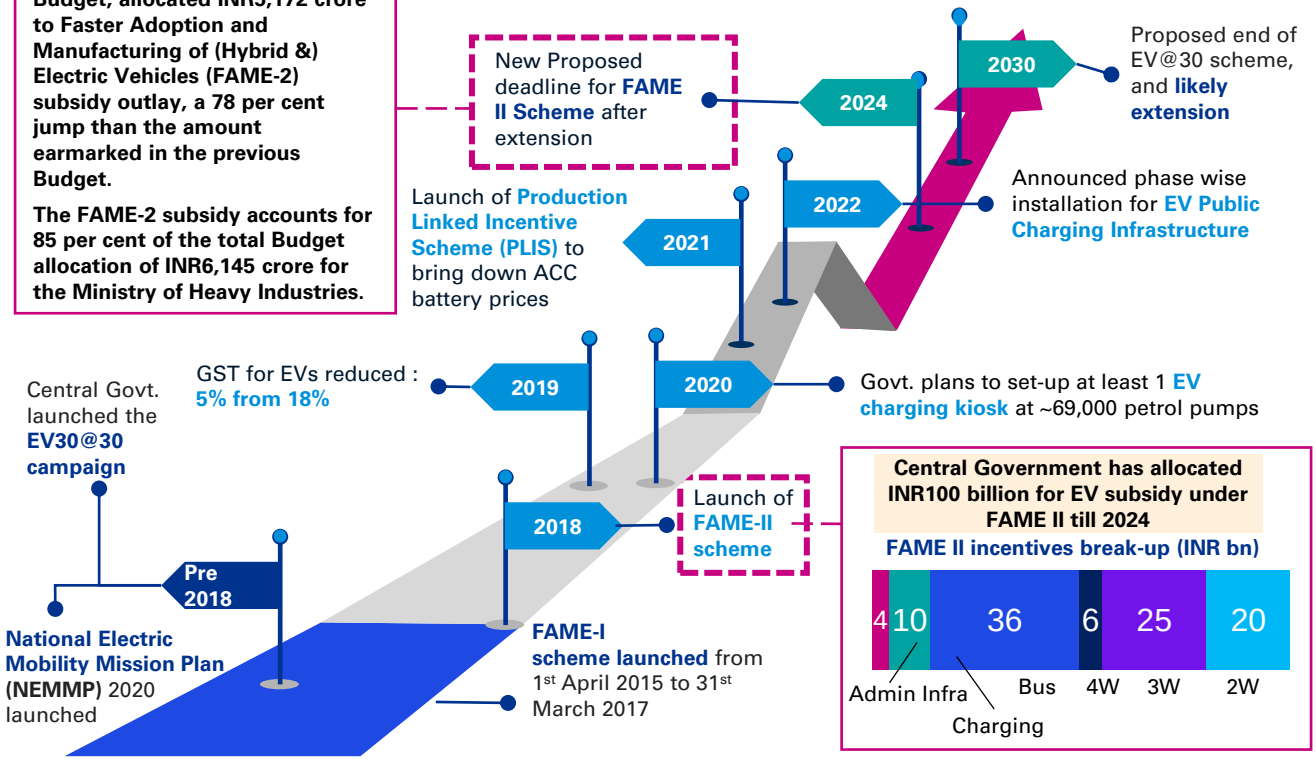
With the country breaking into the top three largest car markets globally in 2022, it is essential to swiftly transition from ICE to EV. Aiming to reduce fuel consumption and mitigate carbon emissions, the central government has been increasingly pushing for the adoption of EVs, through various policy interventions.

INR978,537 crore*
Oil import bill for India in FY22[6]

Fig 2.1 EV adoption roadway in India[7]

The government, in its 2023-24 Budget, allocated INR5,172 crore to Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME-2) subsidy outlay, a 78 per cent jump than the amount earmarked in the previous Budget.

The FAME-2 subsidy accounts for 85 per cent of the total Budget allocation of INR6,145 crore for the Ministry of Heavy Industries.



1. COP27: Report sees slight rise in 2022 global emissions; highest in India, Down to Earth, 11 November 2022
2. 39 Indian cities among world's 50 most polluted, Times of India, 15 March 2023
3. Lancet study: Pollution killed 2.3 million Indians in 2019, BBC, 18 May 2022
4. Air pollution not only bad for health but for economy too, Financial express, accessed on 30 March 2023
5. How EVs can help decarbonise india's transport sector, Mobility Outlook, 7 September 2022
6. India's FY22 crude oil imports hit 8-year high in value terms, Business Line, 25 April 2022
7. e-Amrit website

Along with the national policies, 26 states have announced EV focused initiatives with the goal of promoting EV usage and EV component manufacturing. These policies provide a variety of incentives to boost EV demand, manufacturing, and infrastructure development [1].

Fig 2.2 EV targets for select state governments[1]

State	Goal	Target year
Delhi	100 per cent conversion in last mile fleet	2030
Uttar Pradesh	1 million EVs on road	2024
Madhya Pradesh	25 per cent of all new registered vehicles to be electric	2026
Punjab	25 per cent of new e2W, e3W sales in target cities	2024
Gujarat	200,000 EVs on road	2025
Maharashtra	10 per cent EV's for all new vehicle registrations	2025
Andhra Pradesh	1 million EVs on road	2024
Haryana	100 per cent electrification of public transport buses	2029
Odisha	20 per cent of all new registered vehicles to be electric	2025
Assam	2,00,000 EVs on road or 25 per cent of all new registered vehicles to be electric	2026

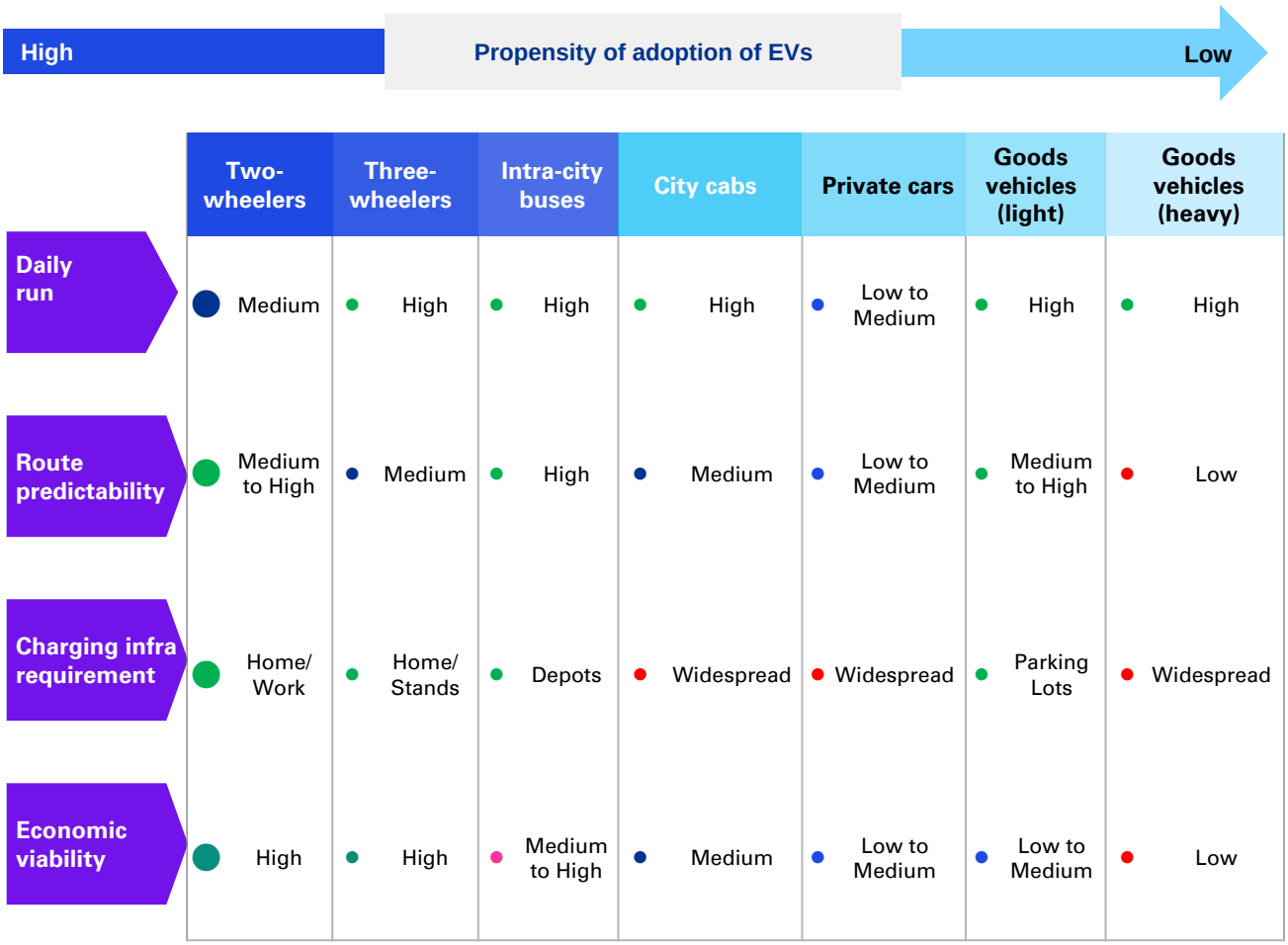
The transition to EVs is critical to India's economic resilience and sustainability goals and presents an opportunity for the country to mitigate climate change, as well as reduce its dependence on oil. Enabling policies both, at a national and state level have made the environment conducive for e-mobility in India, helping drive towards its goal of achieving 30 per cent electrification of the country's vehicle fleet by 2030.

1. e-Amrit website

3 Vehicle segments that are championing the shift

2022 was a prominent year for EV sales in India, as the number of EVs sold surpassed the one million threshold. This was largely contributed by the sales of 2Ws and 3Ws, since these categories satisfy majority of requirements for switching to an electric fleet. High route predictability, high economic viability and ability to use home or private chargers for charging in 2Ws and 3Ws are some factors that have aided in the shift[1].

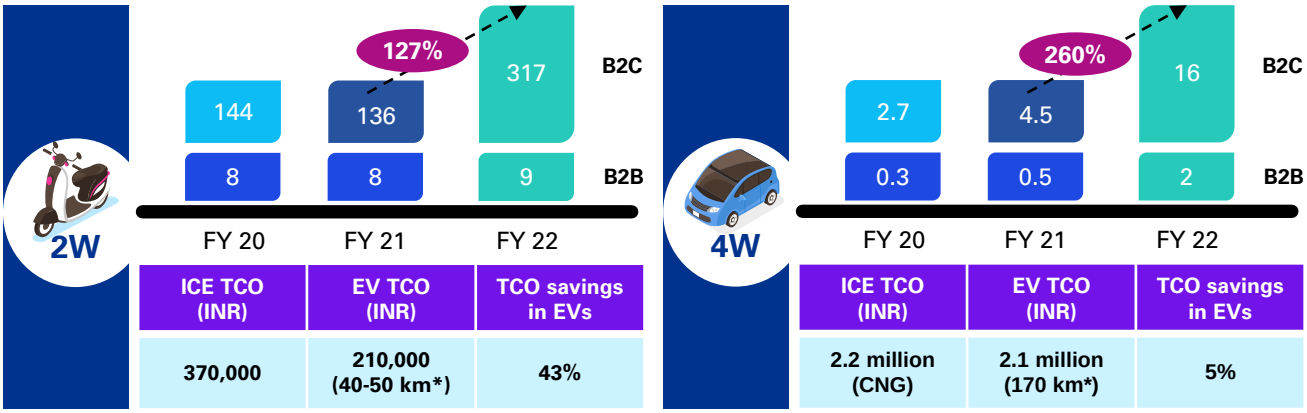
Fig 3.1 Propensity of adoption of EVs[1]



	Two-wheelers	Three-wheelers	Intra-city buses	City cabs	Private cars	Goods vehicles (light)	Goods vehicles (heavy)
Daily run	Medium	High	High	High	Low to Medium	High	High
Route predictability	Medium to High	Medium	High	Medium	Low to Medium	Medium to High	Low
Charging infra requirement	Home/ Work	Home/ Stands	Depots	Widespread	Widespread	Parking Lots	Widespread
Economic viability	High	High	Medium to High	Medium	Low to Medium	Low to Medium	Low

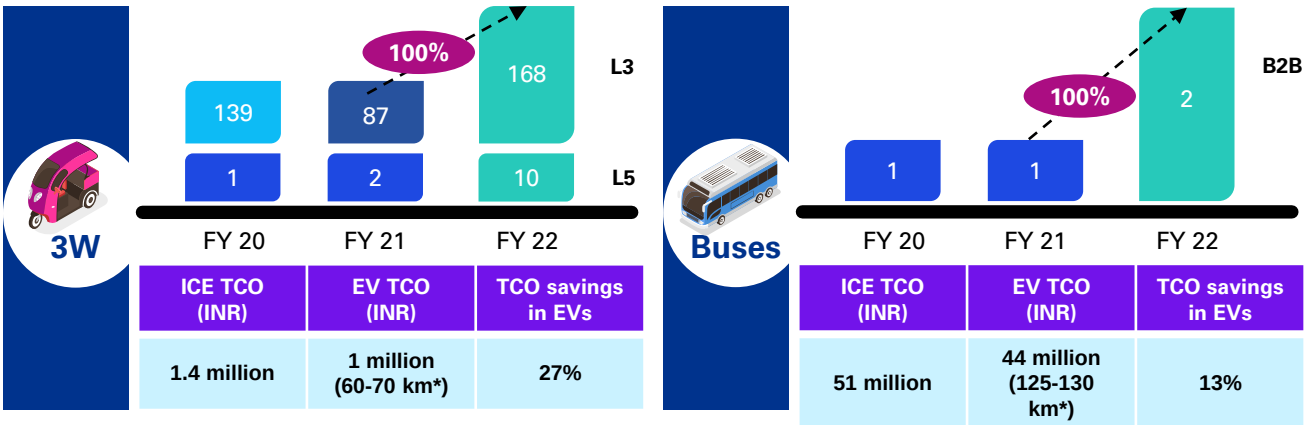
1. KPMG in India analysis

Fig 3.2 Overall EV sales in India - B2B + Retail ('000 units)[1]



ICE TCO (INR)	EV TCO (INR)	TCO savings in EVs
370,000	210,000 (40-50 km*)	43%

ICE TCO (INR)	EV TCO (INR)	TCO savings in EVs
2.2 million (CNG)	2.1 million (170 km*)	5%



ICE TCO (INR)	EV TCO (INR)	TCO savings in EVs
1.4 million	1 million (60-70 km*)	27%

ICE TCO (INR)	EV TCO (INR)	TCO savings in EVs
51 million	44 million (125-130 km*)	13%

Y-o- Y Growth

*Minimum kms to be travelled per day to achieve TCO parity

*Note: 1 Low speed e2W number for FY22 not reported CY21 numbers have been considered as estimate for FY22, 3W passenger sales volume which were predominantly ICE fell in FY21 translating to higher EV penetration

Growth in EVs is expected to continue for the rest of the decade, with 2Ws and 3Ws sales expected to dominate other segments. EV adoption is expected to see an inflection point once all vehicle segments show significant ownership savings over ICE vehicles.

1 Society Of Manufacturers Of Electric Vehicles, Discussions with leading automobile and automotive component players in the country

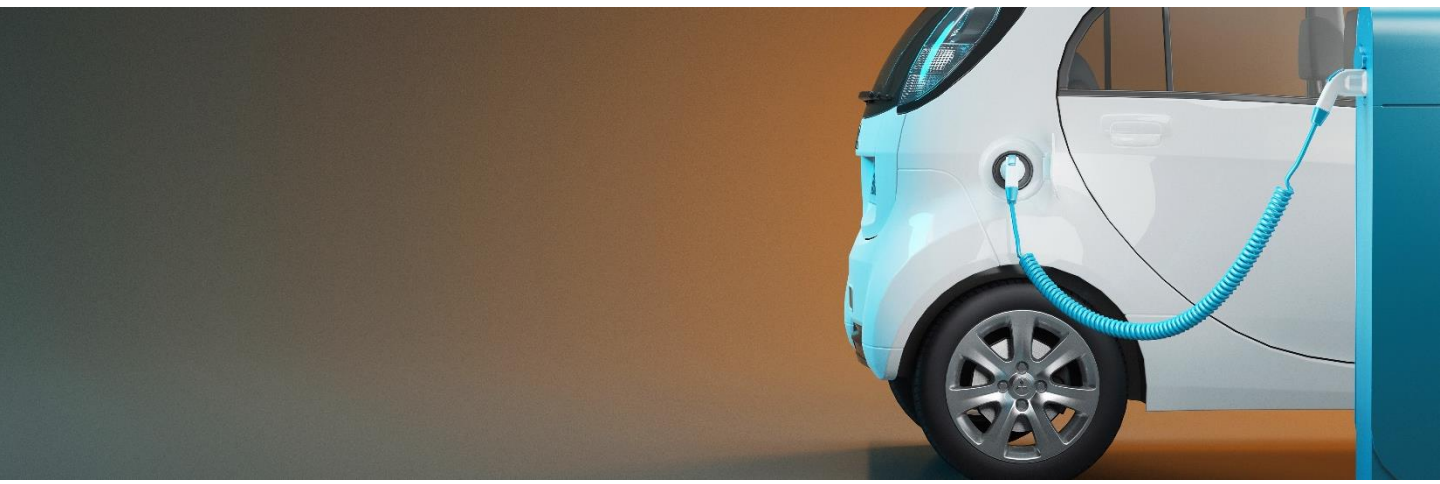
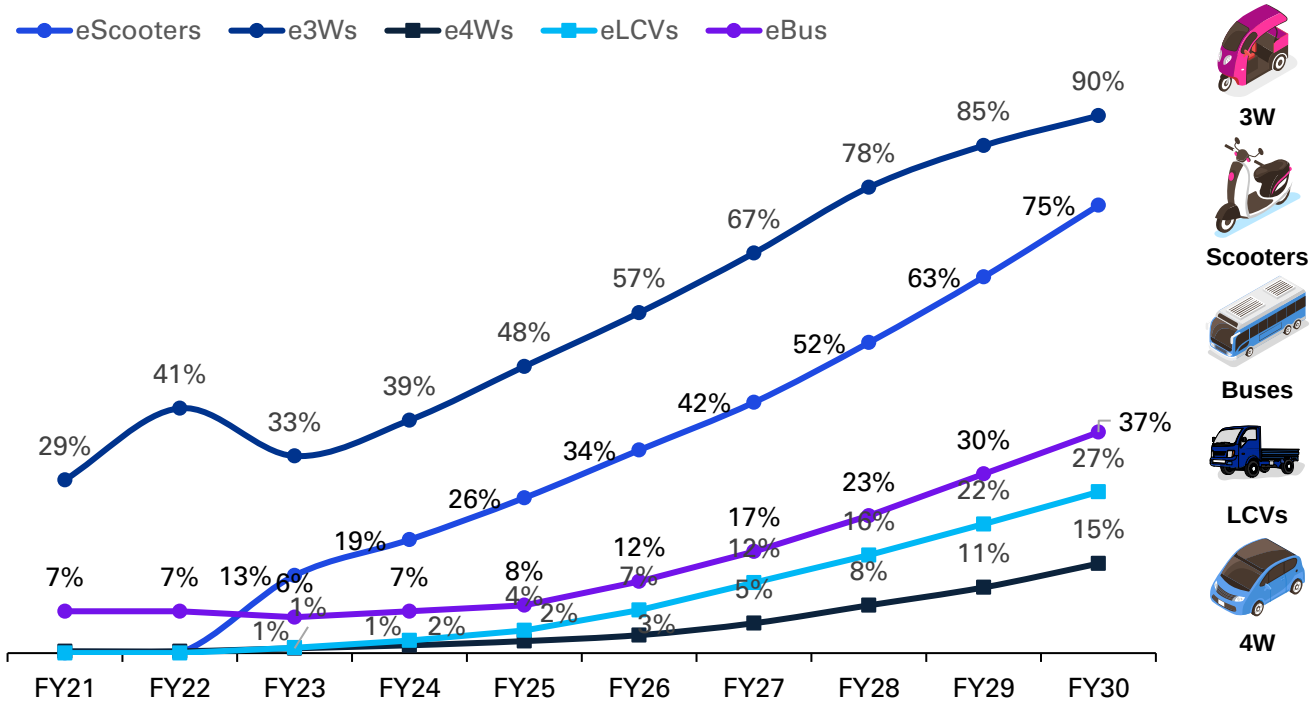


Fig 3.3 Forecasted penetration curve for EVs by vehicle category[1]



Inflection points are likely to be different for each segment as different factors will play a critical role for each segment[1].

- **4W:** B2B (commercial users) is currently the key customer base driving e4W sales, given parity in TCO between 4W ICE and EV with high daily usage and increasing fuel prices. Significant penetration in vehicles for personal use is expected to start picking up in the next four to five years, driven by decreasing battery prices and increasing fuel prices.
- **Buses:** Government-run public buses are expected to have a greater penetration as a result of the subsidies and programmes aimed at accelerating their adoption. Limited offtake is expected in the private segment, given high upfront cost differential (~3x–4x) and subsidies being limited only to the public segment.
- **Light commercia vehicles (LCVs):** The viability of electrifying LCVs is stronger than for 4Ws in situations like urban delivery since LCV fleets are driven extensively, operate on predictable routes, and can be charged at commercial depots. More favourable government schemes and comparable models to ICE could drive higher penetration

India is gradually adopting EVs, with 2Ws and 3Ws leading the way on account of positive TCO over ICE. Favourable government policies, robust charging infrastructure and focus on decreasing the cost of ownership are likely to lead to higher penetration of other segments such as 4Ws, buses and LCVs.

1. KPMG in India analysis

4 As we shift from ICE to EVs, there is also a shift in the quantum of technology inside and outside a vehicle

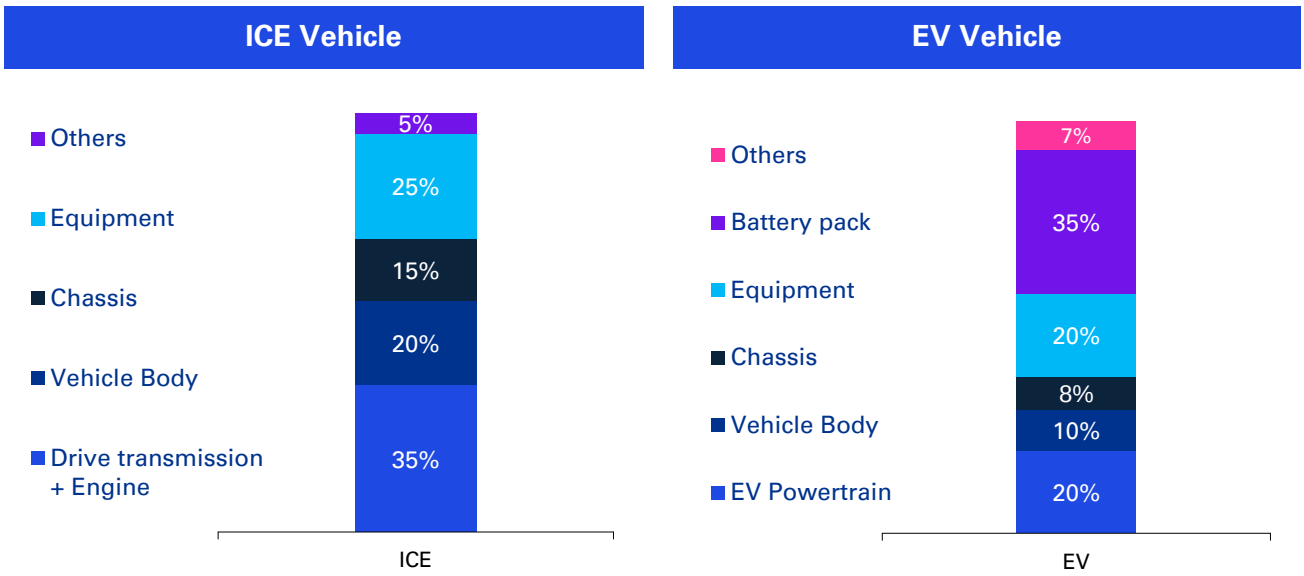
The interior and exterior of an EV varies significantly in terms of the technology used. The inside of an EV has seen the addition of new technological components such as Battery Management System (BMS), motor controller, touch dashboard, battery technology, motor technology and telematics. The EV ecosystem has also seen an extensive technology evolution i.e., value chain and support infrastructure such as vehicle financing, charging infrastructure, insurance technology, cloud computing/data analytics, leasing, online sales channel, and end-of-life vehicles (ELV) or circular economy.

4.1 Parts of an EV being integrated with technology

The components used inside an EV are going through a major change with increasing use of technology and software. Following are some of the major developments witnessed inside an EV:

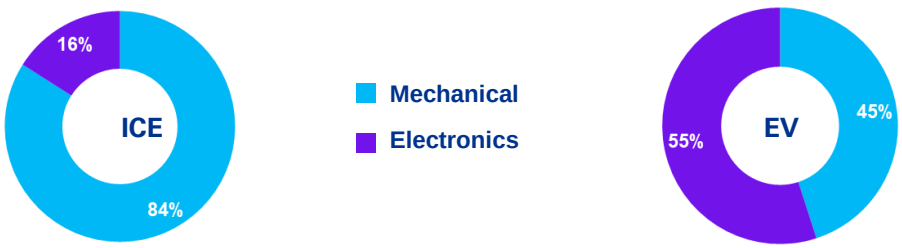
- The engine has been replaced by battery with a technology addition of BMS
- Transmission has been replaced by motor and controller
- Normal analogue screens have been replaced by digital touch screens
- Increasing number of ECUs with advanced software programming

Fig 4.1 Comparison of ICE and EV vehicle components[1]



These transitions are leading to an increase in the electronics content **from 16 per cent** in traditional ICE vehicles to approx. **55 per cent** in an EV.

Fig 4.2 Share of electronics in total vehicle BOM cost for 4W[1]



1. KPMG in India analysis

Way forward:

- The automotive ecosystem will have a long-lasting impact due to the EV transformation. A large portion of this ecosystem will need to be rebuilt, re-skilled, and expanded to meet the future needs of EVs. EVs have shown to be not only a cleaner option to fossil-fuel-powered vehicles, but also have significantly lower operating cost over the vehicle's lifecycle.
- As EV technology evolves, new suppliers of crucial components such as power electronic components, batteries, software, etc. have an opportunity to enter and challenge the established companies to diversify.

• BMS has evolved from a simple Protection Circuit Module (PCM) to advanced BMS

A BMS is a critical part of any battery system that controls and monitors the state of charge, temperature, current and voltage of the cells in the battery pack. A PCM is incapable of smart energy management and is thus more prone to failure under non-standard operating conditions. One of the consequences of such failure is battery fires that has been witnessed quite regularly in the past few months. Nine EV fire incidents of electric two wheelers have been reported since March 2022, with a total of 20-30 vehicles involved. An advanced BMS provides the right mix of safety and performance by balancing the energy stored in the cell thus preventing fire incidents.

Fig 4.3 Evolution of (BMS)[1]

PCM

- Primitive stand-alone protective circuit
- Focuses on protection from under/over current or voltage flow
- Purely hardware based with no software integration for decision making
- Lack of any precision output
- Performs equalisation using a basic model
- Low cost to produce
- Used in small electric tools and low-end bikes

BMS

- Advanced circuit with multiple functionality
- Significant focus on intelligent software integration in addition to hardware
- High level of precision and adaptability
- Measures, operates and protects the battery packs using advanced algorithms
- Used across advanced products like EV, drones, etc.

Fig 4.4 How BMS can save from battery fires[2]

1. **Over-discharge protection** – This prevents the battery from being discharged below a certain safe level.
2. **Short circuit protection** – This protects the battery against short circuits between cells or between an electrode and the ground.
3. **Thermal runaway protection** –This offers protection by activating and shutting down the battery to prevent it from overheating, when temperature of a cell gets too high.
4. **Cell balancing** – This ensures each cell in the battery pack is equally charged and prevents damage to the cells and uneven charging.
5. **Current protection** – This protects the battery against excessive charge or discharge currents.
6. **Overcharge protection** – This prevents the battery from overcharging, which helps minimise or prevent damage.

- Battery management systems available in the market are completely reliant on the manufacturer, with varying degrees of efficiency. Given the system's complexity and range of functions, there is an urgent need for standardisation. OEMs must further improve the BMS design with compact batteries to maximise performance and minimise energy loss.
- Interoperability of batteries through swapping requires standardised BMS across vehicle segments.

1 PCM vs. BMS: Which is better, ION Energy, 13 June 2022, as accessed on 22 March 2023
2 What is a BMS protection board of lithium battery, Tritek, as accessed on 22 March 2023

- **Motor controller is responsible for regulation of driving conditions and protects the motor and overall mechanics**

Another major component of an EV is the motor controller which has multiple utilities, creating a differentiator to ICE. The motor controller of an EV efficiently transforms the energy stored in the batteries into motion using its power elements and micro-processors.

Fig 4.5 Major benefits of motor controller[1]

Major benefits of motor controllers

- **Speed control** of the motor
- **Torque control** to govern the motor's torque delivery
- **Electrical protection** of the motor and subsequently the mechanics
- **Maintaining constant speed**, even after change of loads
- **Dynamic response** to changing system demands even during braking
- **Evaluating machine performance / diagnostics**

Apart from the above stated benefits, motor controller also offers regenerative braking aspects, which are unique to EVs and not available in ICE

Fig 4.6 Unique feature of motor controller in EVs[1]

Regenerative braking function was introduced to EVs to leverage kinetic energy from the electric motor when the car slows down. The mechanism captures the kinetic energy from braking and converts it into the electrical power that charges the vehicle's battery. This helps batteries to extend range, while also reduces wear and tear on the usual mechanical brake system, further bringing down the maintenance costs.

- **Interactive touch dashboard has been a new addition, replacing the erstwhile analogue displays**

A touch dashboard in an EV is used for control, navigation, and entertainment systems. Touch dashboards play an integral role in providing driver assistance functions available at a single touchscreen platform.

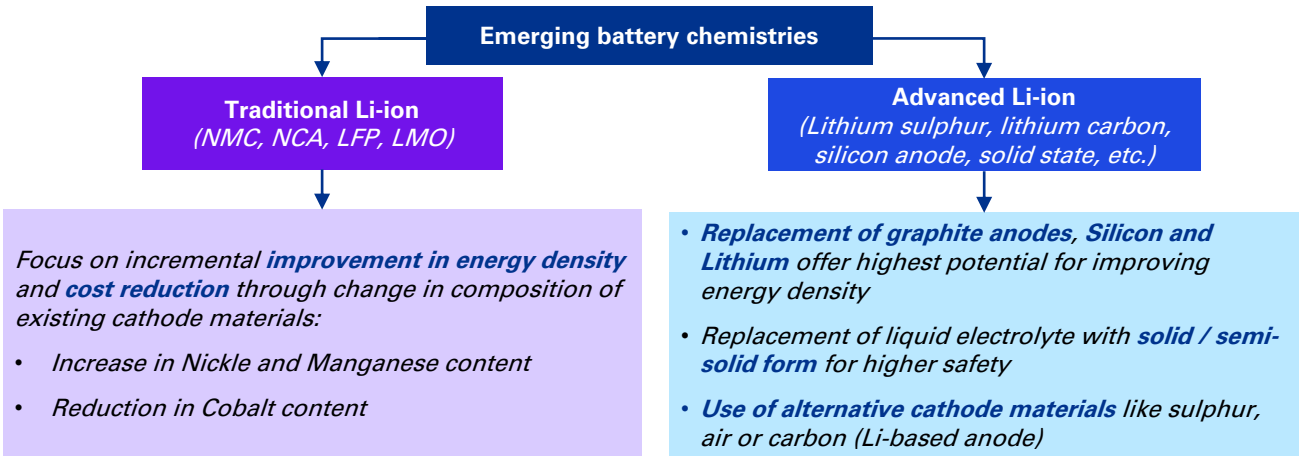
Benefits of a touch dashboard

A touch dashboard provides a user-friendly experience with multiple viewing options and emulates functionality of a smartphone. Most touch dashboards are linked to a mobile application for the purpose of vehicle tracking, vehicle health information and trip analytics. These dashboards have technological features including on board navigation, charging stations tracking, music players, geo-fencing, Over-The-Air (OTA) updates amongst others.

Evolving battery technology

All EVs today use Li-ion battery technology with varying chemistry as per specific requirement of energy density and thermal run-away.

Fig 4.7 Emerging battery chemistries[2]

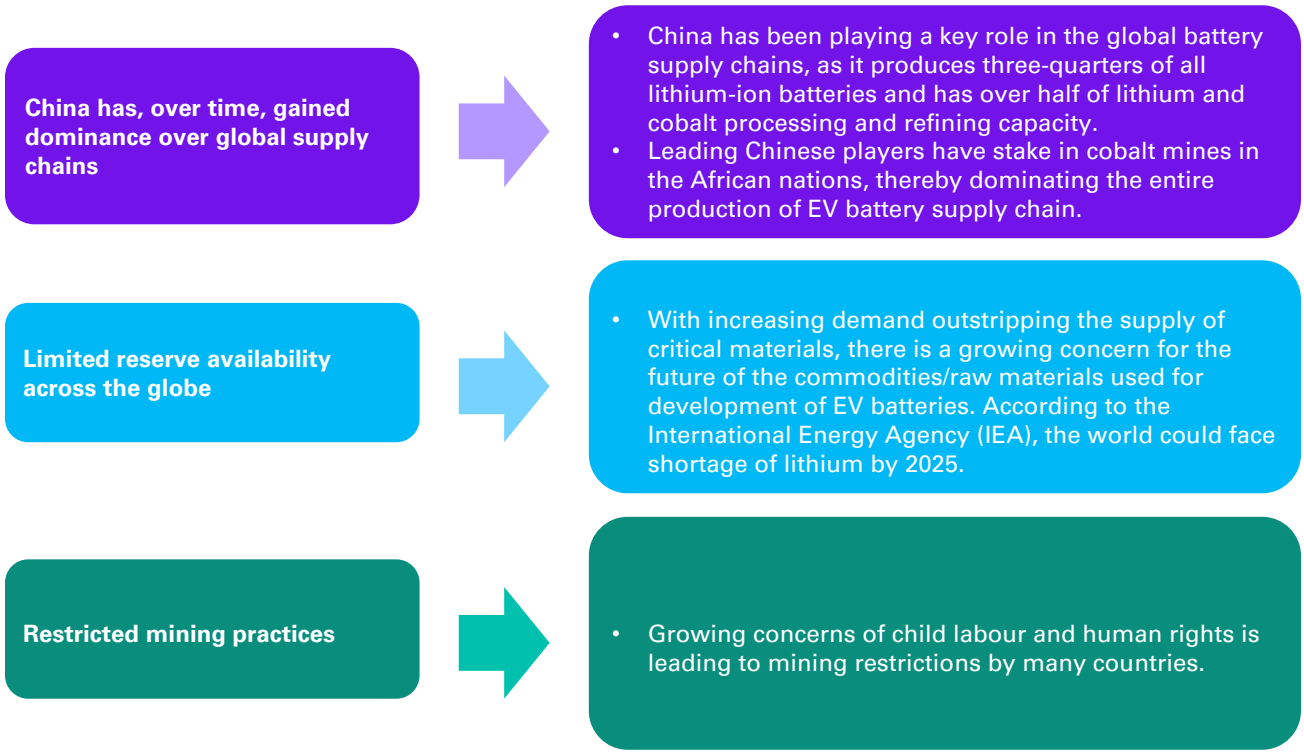


1 KPMG in India analysis
2 IDTech, Industry reports, KPMG in India analysis

- **Development of cell technologies beyond Li-ion and fuel cell to mitigate global supply chain challenges**

Lithium, cobalt, and nickel are the three most critical metals used for the development of batteries in EVs. However, metals and battery supply chains, available today, revolve around China as it is amongst the top five countries with the most lithium reserves. Chinese players have also been purchasing stakes in mining operations in other lithium-rich regions including Australia and South America and cobalt mines in the Congo region[1].

Fig 4.8 Reasons for global supply chain challenges[1]



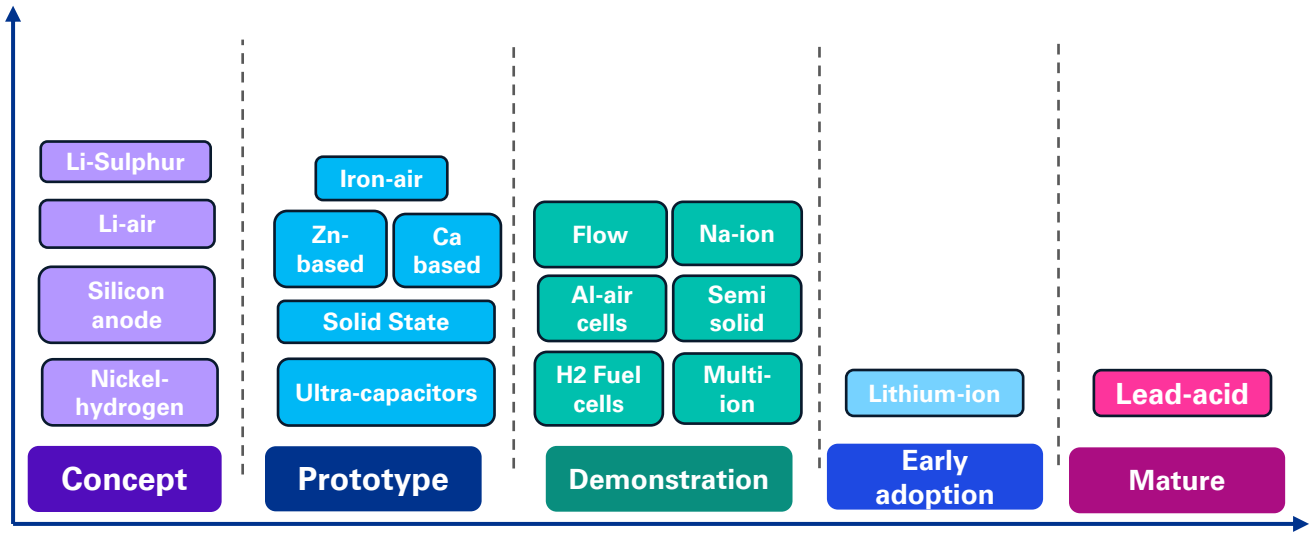
Technology Readiness Levels (TRL) stages in Advanced Chemistry Cell (ACC) space

ACCs are next-generation technologies for development of batteries using alternative raw materials that are either abundant in nature or are cost effective. Manufacturers throughout the world are investing in these new generation technologies to meet the expected surge in battery demand in the next decade. Battery companies are constantly experimenting to develop cutting edge technologies involving hydrogen, sulphur, calcium and zinc that are available in abundance. Companies are making efforts to reduce the cobalt content from batteries due to its questionable mining practices, price volatility, geographical concentration, and use of child labour.[2]

Manufacturers are developing various ACCs that are either in the concept, prototype or demonstration stages. For instance, lithium sulphur, silicon anode, lithium air and nickel hydrogen are still in the concept stages while solid state, iron air, calcium based, zinc based, and ultra-capacitors have reached the prototype stage. Flow, sodium-ion and multi-ion are some of the many ACC in the demonstration phase whereas lithium-ion and lead acid have reached the early adoption and mature stages respectively.

1 IEA, GIZ, Benchmark Mineral Intelligence, KPMG in India analysis
2. India gearing up to make battery cells, leveraging the ACC-PLI, ETN, 8 November 2021, as accessed on 27 March 2022

Fig 4.9 TRL stages in ACC space[1]



While ACCs are being developed globally, there is a need for localisation of Li-ion battery in India. The government of India is therefore undertaking measures for localisation and has rolled out the PLI scheme with an outlay of INR20,557 crore for lithium-ion battery production.*

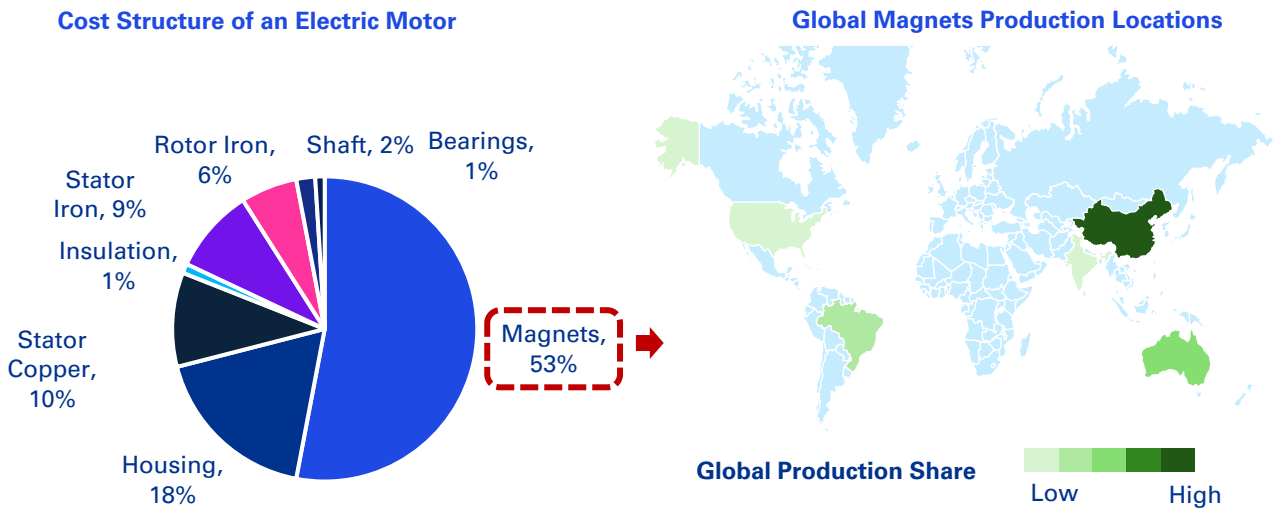
Several non-lithium based chemistries are being piloted by end use industries to achieve a sustainable low-cost battery solution with a few expected to achieve commercial viability by the end of the decade.

- **Innovations in motor technology to de-risk the supply chain**

The performance of Evs directly depends on its electrical motor specifications. Motor performance is determined by the torque-speed and power-speed characteristic of the traction motor. Electric motors used in EVs are primarily dominated by two technologies: Brushless DC (BLDC) motors and Permanent Magnet Synchronous Motors (PMSM). These motors offer high efficiency, high power density, and precise control, making them ideal for use in EVs.

However, both these technologies comprise magnet as a key sub-component, which uses rare metal concentrated in China.

Fig 4.10 Cost structure of electric motor; Dominance of global magnets production locations[2]



1 KPMG in India analysis
2. Rare earths: Scarcity at your fingertips Rare earths: Scarcity at your fingertips, QZ, November 2021, as accessed on 28 March 2023

Currently, China dominates the rare earth elements market (including metals used for magnets) with ~37 per cent share in global reserves and ~70 per cent share in global production[1]. India has a 6 per cent global reserve and 3 per cent global production share in rare earth elements markets. China accounts for ~35 per cent of import value of India's rare earth elements, which is likely to contribute to the high cost and import dependence in domestic EV manufacturing.

However, stakeholders in the Indian EV landscape are trying to solve this issue with technologies on two fronts:

- **Development of magnet-less motors:** Dependence on rare earth metals can also be reduced through the development of the magnet-less synchronous reluctance motors (SynRM), suited for high-speed application due to its robust nature. SynRM also offers high power density, wide constant power operation region and fault tolerance. The absence of magnets also eliminates the challenge with mechanical forces, enabling the motor to operate at a high torque-speed. However, due to its high manufacturing cost, SynRM technologies currently have high prices in the market. This technology is likely to receive greater focus from EV players and customers with innovations focused on lowering its cost.
- **Reducing dependence on rare earth metals in current BLDC and PMSM motors:** There has been increased focus on developing improved low-cost rare earth-free magnets. This is likely to lead to lower manufacturing cost of BLDC and PMSM, as rare earth magnets are key components of these technologies.

Fig 4.11 Comparison table of major motors in EVs[2]

Characteristic	BLDC	PMSM	SynRM
Components	Permanent magnets constitute the major cost	Permanent magnets constitute the major cost	Copper and steel constitutes the major cost. Magnets are not present
Noise level	Moderate	Low	High
Manufacturing cost	Moderate	High	Low
Efficiency	Moderate	High	Low
Usage / Application	Low and city speed E2W and E3W	High speed E2Ws, E4Ws, E-LCV and E-Bus	Currently a developing technology as an alternative to PMSM motors to counter the increasing usage of magnets

1 Rare earths: Scarcity at your fingertips Rare earths: Scarcity at your fingertips, QZ, November 2021, as accessed on 28 March 2023
2. KPMG in India analysis

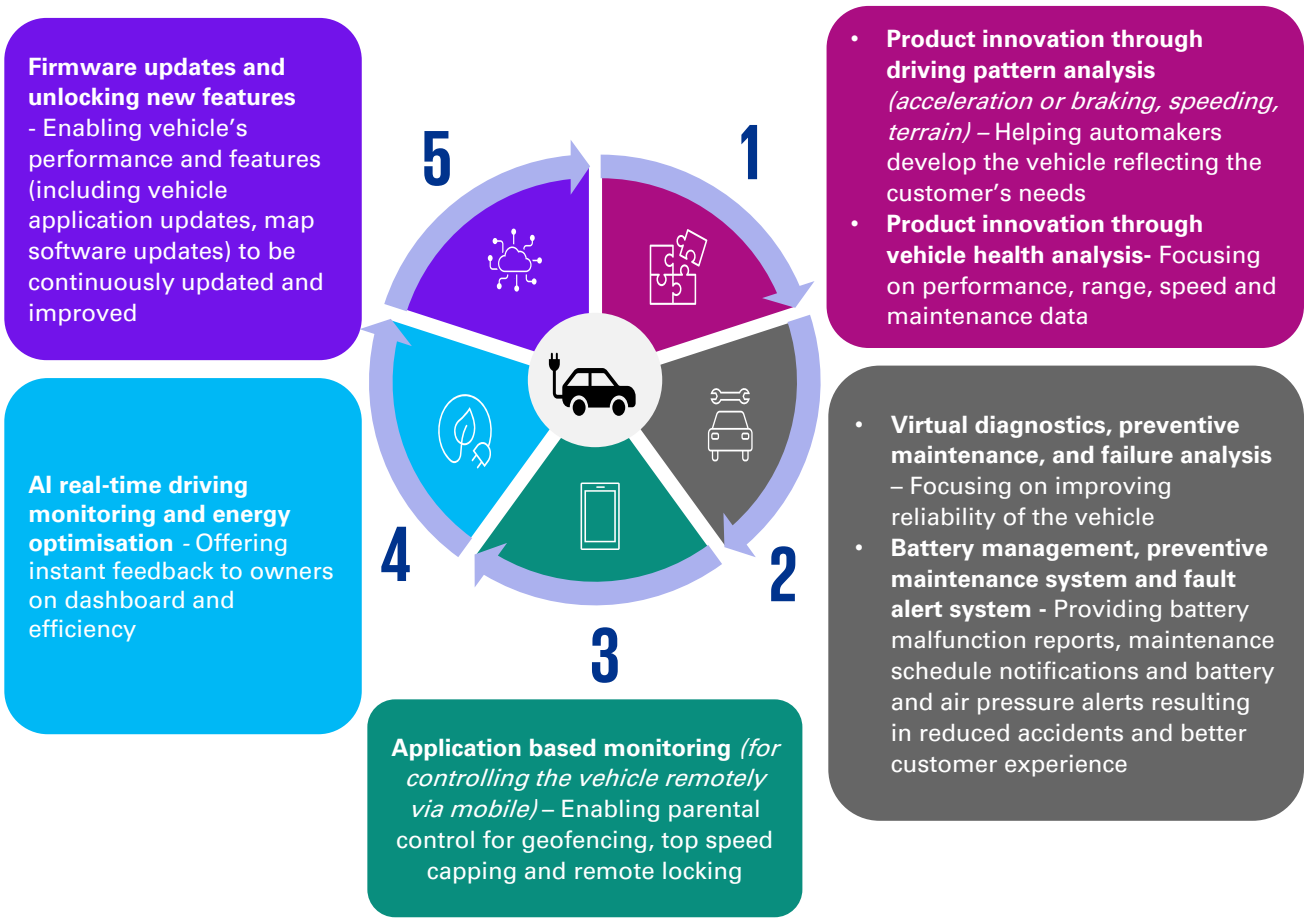
- **Advanced telematics and Internet of Things (IoT) are becoming standard technology**

Telematics is the use of integrated technology and communications to store, transmit and receive data between devices with the help of a telecom service. It refers to the convergence of telecommunications and information processing. In the era of connected technology, EVs also require telematics and IoT for multiple applications. Some of these applications are:

- Real time location tracking and navigation
- Improving driver's experience
- Continuous charging updates
- For providing vehicle to grid communication

Advanced telematics and IoT enable **quick product innovation, virtual diagnostics, artificial intelligence (AI) real-time driving monitoring, application-based monitoring**, and **OTA updates**.

Fig 4.12 Advance telematics and IoT enabling quick product innovation, virtual diagnostics, application-based monitoring, and OTA updates[1]



1. KPMG in India analysis

4.2 Technology permeating into support infrastructure and ecosystems as well

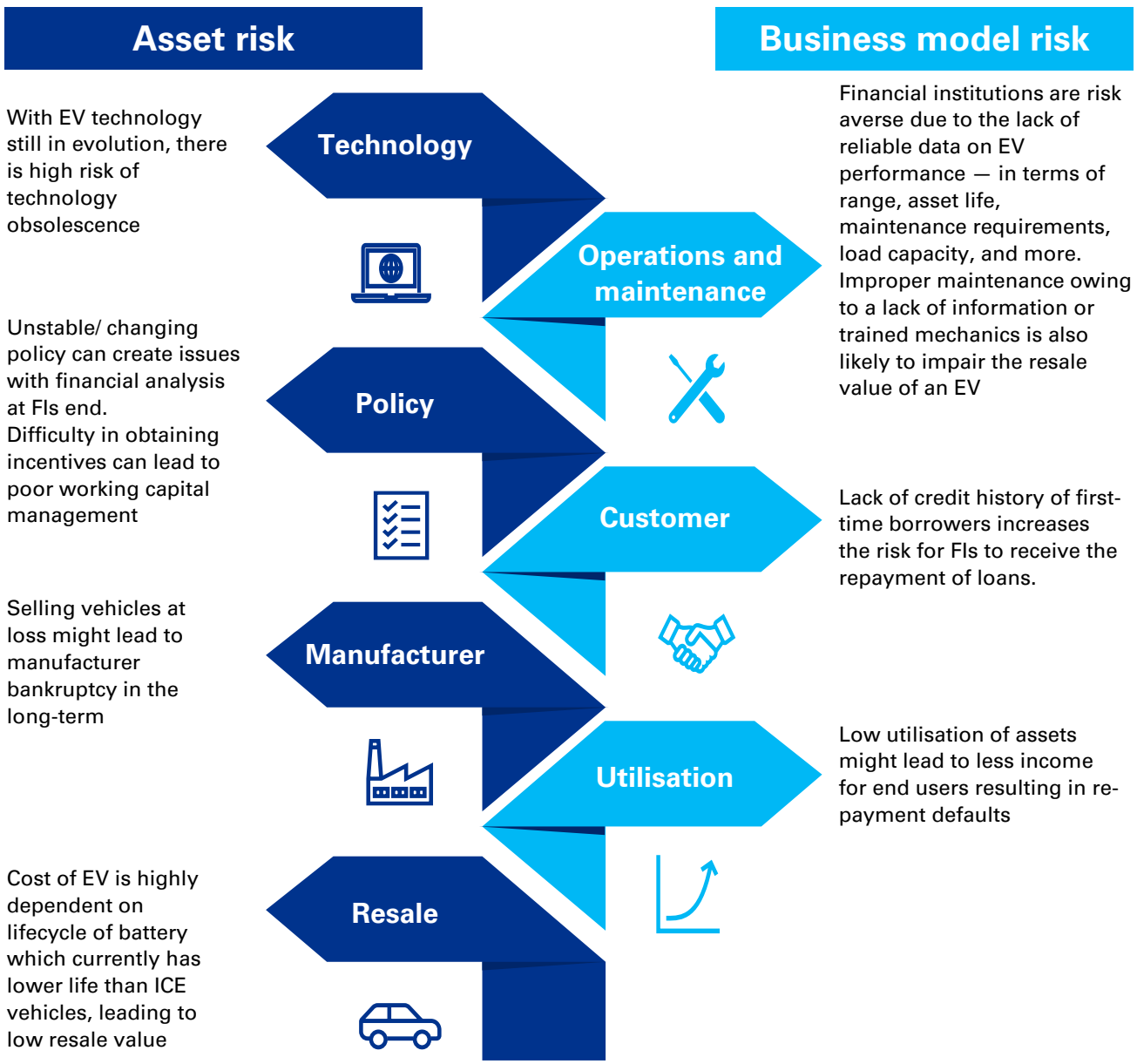
- **EV financing is witnessing innovative solution from Non-Banking Financial Companies (NBFCs) and start-ups**

EV financing has its unique set of risks and challenges

Conventional vehicle financing companies are reluctant to finance the EVs due to the risk associated with both business models and assets. Some of the unique set of risks associated with EV financing are:

- High operations and maintenance cost, low utilisation, technology obsolescence, customer defaults, manufacturer bankruptcy, policy changes and low resale value.
- On the other hand, higher interest rates, low loan-to-value ratios, limited financing options, and high insurance rates are some of the challenges that are leading to low confidence in EV financing.

Fig 4.13 Types of asset and business model risks leading to limited EV financing options[1]



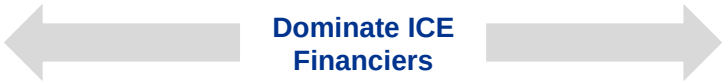
1 Barriers to scaling up finance, EQ Mag Pro, as accessed on 28 March 2023

Current EV financing market map

In the India EV financing market, small NBFCs and fintech lenders are planning to leverage their first mover advantage in the EV lending space. While incumbents are still evaluating their entry into EV financing, small NBFCs and fintech companies are leveraging this gap with the help of technology. The lending rates are sub-par as compared to ICE financing terms; however, the situation is improving as more players are focusing on EV financing terms. However, the situation is improving as more players are focusing on EV financing.

- High operations and maintenance cost, low utilisation, technology obsolescence, customer defaults, manufacturer bankruptcy, policy changes and low resale value.
- On the other hand, higher interest rates, low loan-to-value ratios, limited financing options, and high insurance rates are some of the challenges that are leading to low confidence in EV financing.

Fig 4.14 Current EV financing market map[1]



	Small NBFCs	Fintech lenders	Public sector banks	Private banks	Captive NBFCs	Mid + large NBFCs
Description	Small NBFCs have asset under management (AUM) range of over INR107 crore*	Fintech lenders are NBFCs that focus on providing digital loans. These lenders have AUM range of INR58-436 crore*	Majority government owned banks with AUM range of more than INR109,613 crore*	Mostly listed large privately held banks with AUM range of more than INR109,613 crore*	Financing arm of OEM groups with AUM range of INR10,937-54,847 crore*	Independent large scale NBFCs with AUM range of more than INR1,069 crore*
EV segments	2W and 3W	2W and 3W	2W and 4W	4W	Own 2W, 3W, and 4W	Limited play on case-to-case basis
Lending rates (Sub-	B2C: 23-26 per cent	B2C: 23-26 per cent	B2C: 12-15 per cent	B2C: 12-15 per cent	B2C: 20-23 per cent	NA
Borrowing rates (Indicative)	10-15 per cent	10-15 per cent	3-5 per cent	3-5 per cent	8-9 per cent	6-9 per cent

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Innovation in EV financing

Companies in EV financing space are continuously focusing on innovations to overcome risk and challenges with the help of technology.

Fig 4.15 Innovation in EV financing[1]

Geotagging

- Geotagging is used to create boundary conditions on driving range. A notification is provided to the financial institutions for further actions, in case a driver breaches that boundary.
- Financial institutes are using geotagging to understand if the owner of 3W EV is challenging to underwrite as the owners are mostly semi-literate with no credit history and reside in geographies that are unserviceable.
- Financial institutes are leveraging digital technologies and high smartphone penetration in the country to successfully provide financial services to this customer base.
- Digital lending platforms use a blend of data-driven tools like machine learning, algorithms and non-traditional data tools like psychometrics, SMS, and biometrics to make their underwriting decisions. This also eliminates much human intervention.

IOT and vehicle tracking device

IOT helps financial institutions in the following ways:

- To access utilisation data of asset and limit risk of defaults in low utilisation cases
- Financial institutions can get in contract with OEMs to access vehicle performance data and provide financing terms basis vehicle quality
- IoT is also being used for maintenance schedule alerts and regular battery health reports to the financial institutes and owner of a vehicle
- Using battery health data and its proprietary underwriting model, financial institutes extract a high residual value for EVs, helping customers get an effective interest rate of **7 per cent.** This is almost at par with the return on investment (RoI) offered by PSU banks for conventional vehicles with an internal combustion engine (ICE).

Automated deductions

- Fintech companies are looking to drive digital payments in the commercial e-rickshaw first/last-mile delivery segment.
- As most drivers are smartphone equipped, they can receive fare/payment in their e-wallets as well as pay their EMIs. This allows daily/weekly repayment schedules for B2B customers insuring proper utilisation and automated debit from customer's account.

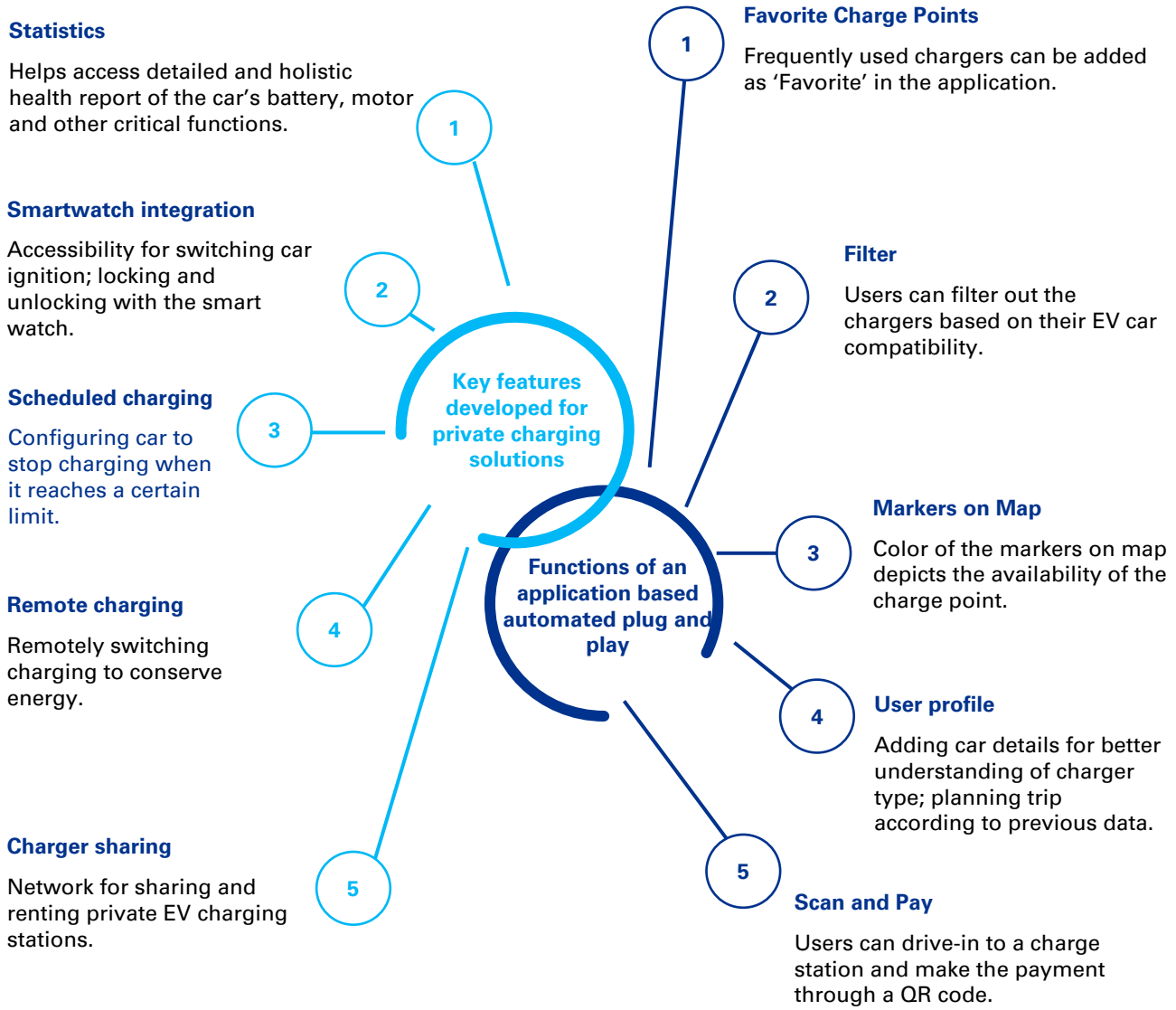
At present, the EV financing sector is mostly dominated by small NBFCs and fintech companies as they offer easy financing solutions. With the entry of large public and private banks, NBFCs will start offering better financing conditions in terms of disbursal percentage and lower interest rate.

1 How fintech can provide innovative financing solutions to India's EV sector, The Economic Times, as accessed on 28 March 2023

• Charging solutions are evolving to provide fast, seamless experience to end-users

The advancement of charging solutions is following a typical pattern of innovation that boosts functionality as well as making components more affordable. Additionally, software innovations are already addressing various scaling issues and is likely to be crucial for EV uptake. With application-based integration evolving, home/private charging solutions are supporting the users in energy management, remote monitoring, warranty, and service management, while application integration in plug and play operations is making public charging process simpler.

Fig 4.16 Key features developed for private charging solutions and functions of an application based automated plug and play[1]



A nation-wide master application serving as a one-stop shop providing information on the location and availability of car charging stations could speed up the adoption of EVs and reduce range anxiety among end users.

1 Guide To Use EV Charging Mobile App, Numocity, as accessed on 28 March 2023

Technological innovation in charging solutions is not limited to application-based technologies. Faster charging technologies, integration with digital payment platforms, wireless charging, smart features (with sim enabled chargers) are being developed globally to address long charging time concerns and peak power demand management. AI, IoT, and other cutting-edge technologies can enhance utilisation while maximising the effectiveness and performance of products.

Fig 4.17 Upcoming charging technologies[1]

Fast charging: Fast charging technologies are being developed globally to address long charging time concerns and boost adoption:

- **HyperCharging**: Technology with the capability to charge 24 vehicles simultaneously and equipped with modular systems, enabling it to install 70 per cent faster than other charging systems. Innovation in this space has led to delivering power at 1000kW and charge EVs within 6 minutes.
- **Megawatt Charging System**: MCS has been formed to meet the requirements of **new commercial vehicles (trucks, buses)** with high power charging solution for battery packs that can **accept over 1 megawatts of charging rate** using Combined Charging System **(CCS) technology**.
- **New fluid cooled cables**: New cooling technology for EV high-current charging cables enables **delivering current at 4 times** that of the fastest available EV chargers on the market, reducing the charging time and makes it possible to use smaller wire diameter inside the charging cable.

Wireless charging

- Wireless EV charging technology has significant potential in overcoming some of the challenges facing the widespread adoption of EVs, such as range anxiety and the inconvenience of frequent recharging.
- The technology can be particularly helpful for electric buses as it could **reduce operating costs**, making them more affordable with **smaller batteries and extended battery life.**

Payment options in charging systems

- Charging systems integrated with payment solutions are likely to help users have the choice of paying with cash or using other methods such as credit**/debit cards, cryptocurrency wallets, or other payment methods.**
- Another technology, the **Tap & Charge** payment processing system, provides an efficient solution for business owners seeking a flexible and reliable unattended payment solution for their EV charging stations.

Smart Charging Systems

- Charging systems are being integrated with smart features by **deploying AI, IoT and G2V (Grid to Vehicle) charging process,** which is based on energy availability considering the off-peak and peak load conditions of the grid.
- Smart charging solutions include **V2G (Vehicle to Grid) or bidirectional charging technology,** that enables charging of EV batteries and can also be used to pump electricity back to the grid during peak times.

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- **Distribution channel seeing a disruption with increase in adoption of omni-channel sales**

Apart from traditional offline channels, online sales as a distribution channel is picking up globally with Indian OEMs gradually warming up to the concept. One of the major Indian two-wheeler EV players has already adopted the direct-to-consumer (D2C) sales model for their e-scooters.

Key benefits being offered via the online distribution channel:

- Doorstep product delivery
- Transparency in pricing provided on the application
- Doorstep service through servicing vans
- Integration of financing options

This eliminates the need to set up a conventional dealership network, which would be a resource and cash intensive exercise. The omnichannel strategy involves a mix of physical experience centres and a seamless online sales platform to be topped up by a home delivered product.

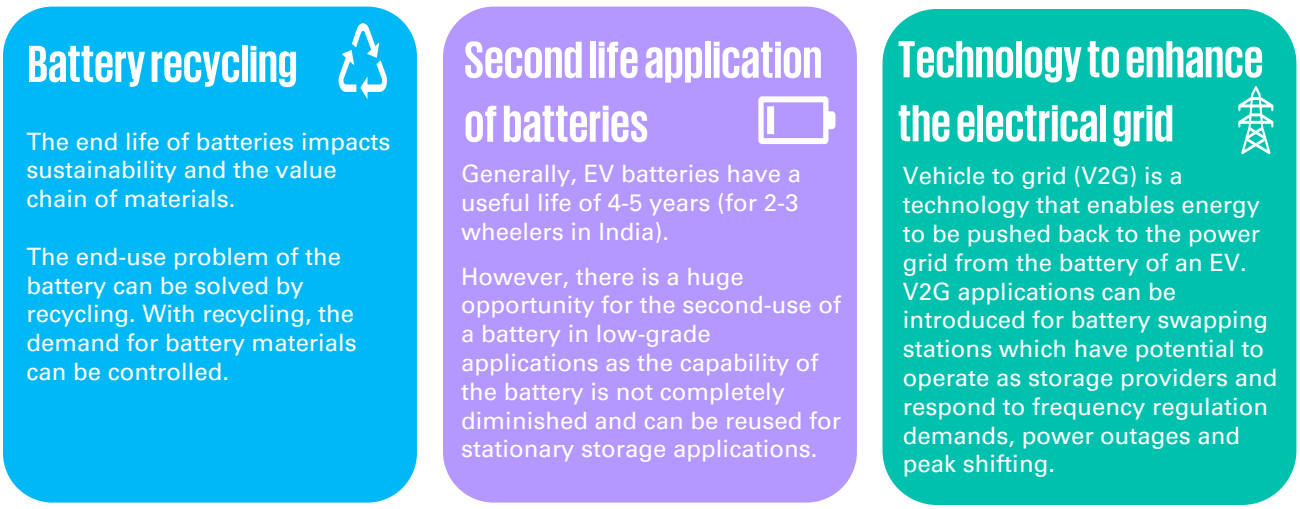
- **End of life solutions becoming a necessity for a sustainable supply chain**

With the increasing number of EVs, there will be a need to have a well-defined end of life solution for EV batteries. The global supplies of raw material are under constraint due to the limited reserves and geopolitical considerations amidst rising demand from the EV segment. The global consumption of these raw materials is expected to increase 20 times by 2030. The five major metals used in manufacturing of an EV battery consisting of cobalt, nickel, lithium, copper and graphite comprise 50 – 60 per cent of the cost of Li-ion batteries.

With China having domestic reserves of most of the raw materials and acquiring reserves in other parts of the world to gain control over the raw material supply chain, there is a huge technology push to develop Li-ion battery recycling capabilities. The recycling technology is still emerging and is taking place in three parts:

- Recycling of battery
- Reuse for stationary storage applications
- Capacities for ancillary services in the power grid

Fig 4.18 Emerging battery recycling and reusable technologies as part of end-of-life solutions



There is a huge technology push to ensure recycling of EV batteries and players are exploring and adopting a variety of process technologies. Example of combination of three methods being explored by players is highlighted below:

Fig 4.19 Combination of methods being explored by players

Mechanical separation – Physical separation of components

Pyro-metallurgical - Processing of spent lithium-ion cells at high temperature

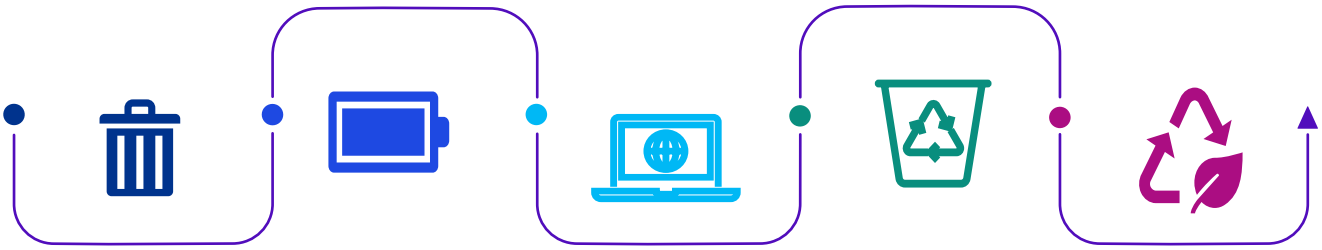
Hydro-metallurgical - Recovery of metal from black mass

Battery waste management is also being supported and encouraged by the Government of India with new battery waste management rules that promotes circular economy for an effective recycling.

Fig 4.20 Regulations for battery waste management[1]

The rules are based on the concept of Extended Producer Responsibility (EPR) where the producers (including importers) of batteries are responsible for collection, recycling/refurbishment of waste batteries and use of recovered materials from wastes into new batteries.

EPR mandates prohibit disposal in landfills and incineration and promotes setting up of new industries and entrepreneurship in collection and recycling/refurbishment of waste batteries.



Battery Waste Management Rules 2022 by the Union Ministry of Environment Forest & Climate Change are designed to ensure environmentally sound management of waste batteries including EV batteries, portable, automotive and industrial batteries.

The rules will enable setting up a mechanism and centralised online portal for exchange of EPR certificates between producers and recyclers/refurbishers to fulfil the obligations of producers.

Mandating the minimum percentage of recovery of materials from waste batteries under the rules will bring new technologies and investment in recycling and refurbishment industry and create new business opportunities.

1 Government notifies Battery Waste Management Rules, 2022, Ministry of Environment, Forest and Climate Change, as accessed on 27 March 2023

5 New business opportunities are emerging from the propagation of EVs

The emergence of EVs has created numerous business opportunities for OEMs, fleet operators, financiers, energy solution providers, technology players, among others. For instance, new features particular to EVs including front boots, remote operations and charging station tracking, are creating opportunities for players across the landscape[1]. This has led to a disruption in the market, creating new opportunities for players across several domains.

Moreover, when compared to ICE vehicles, EVs have new components, and hence, an opportunity for auto component companies who provide vehicle interface, chassis, charging systems, battery management systems, battery accessories and thermal management systems.

• Cell manufacturing – a growing opportunity

The government of India has been focusing on the manufacturing of battery cell components. While India's capabilities in the battery manufacturing value chain are currently limited to pack assembly, initiatives such as the PLI scheme could enhance the domestic cell manufacturing by incentivising players to further develop in this sector.

Fig 5.1 India's capabilities across battery manufacturing value chain[2]

Particulars	Mining	Refining	Active materials	Cell manufacture	Pack Assembly
Level of localisation in India	Low	Nil	Low	Nil	High
Current Status	▪ Miniscule reserves of Lithium, Nickel and Cobalt	▪ PLI for 50GWh ACC scheme	▪ Cathode materials: India doesn't have players ▪ Anode: Few graphite manufacturers exist producing anode materials	▪ Currently importing cells from China and Taiwan	▪ Dominated by Indian OEMs and big battery pack players

The recently launched PLI scheme aims to offer ~INR18,912.9 crore* in incentives for building a 50 Giga Watt Hour (GWh) ACC manufacturing capacity. Additionally, NITI Aayog has laid out a strategy to capture the huge storage opportunity in the EV segment, with a target of localising 80 per cent of the value chain by 2030[3].

Fig 5.2 PLI Scheme for ACC battery storage[4]

Scheme details	Key eligibility criteria	Incentive rollout
▪ Manufacturing capacity of 50 GWh of ACC and 5 GWh of "Niche" ACC ▪ Outlay of ~INR18,913 crore* ▪ Incentives only for cell manufacturing and not for conventional battery pack assembly	▪ Set-up an ACC manufacturing facility of minimum five GWh capacity and maximum 20 GWh capacity ▪ Incur mandatory investment of INR230 crore*/GWh ▪ Domestic value addition of at least 25 per cent within first two years and 60 per cent within five years either at the Mother Unit level or at the project level	▪ Selected bidder entitled to receive fiscal benefits in the form of cash subsidy ▪ Subsidy limit of INR2,055*/kWh ▪ Incentive would be distributed over a five-year period, with greater specific energy density and cycles and enhanced local value addition ▪ No restriction on chemistry or technology

1. "11 unique features found in modern electric vehicles", Royal Automobile Club of Victoria (RACV), 12 December 2022, as accessed on 20 March 2023
2. GIZ, KPMG in India analysis
3. NITI Aayog, KPMG in India analysis
4. National Programme on ACC Battery Storage policy document, Secondary Research, KPMG in India analysis

• Hub of electronics and semi-conductor manufacturing

India has the potential to become a significant participant in electronics and semiconductor product manufacturing as part of the China-plus-one diversification strategy. Over the last decade, the country's electronics and semiconductor product manufacturing sector has grown tremendously.

- In 2014, India's electronics ecosystem which includes manufacturing, design, innovation, and production, was valued at INR82,230 crore* by 2022, it had grown to INR616,725 crore*, and is predicted to surpass INR2,466,900 crores* by 2025-26.
- The electronics and semiconductor industries received 66 per cent of the FDI that flowed into India over the last three years.
- The India Semiconductor Mission (ISM), a business division of the Digital India Corporation aimed at promoting the growth of the country's semiconductor and electronics manufacturing industries, is currently evaluating business proposals from several investors to establish fabs and chip manufacturing facilities in the country[1].

• The charging infrastructure is another area of focus

In India, the development of charging infrastructure is transitioning away from standalone charging stations with dedicated area for multiple chargers to fragmented installations of destination-based chargers. For EVs, any parking site with access to an EV charging point can make vehicle battery charging more feasible. This charging infrastructure implementation strategy promotes the installation of charging points at various locations. Such a strategy provides multiple benefits to users and operators, ranging from ease of access to financial feasibility[2].

Fig 5.3 Charging solutions beyond standalone charging stations

Charging solutions beyond standalone charging stations			
Home/workplace charging	**Destination charging**	**Fleet charging**	**On-the-go charging**
▪ Affordable charging hardware ▪ Easy installation ▪ Measure power consumption ▪ Mechanism for billing	▪ Easy access and availability ▪ Minimal charging tariffs ▪ High charging speeds ▪ Easy search and quick billing	▪ Convenient, accessible ▪ Network uptime and charging speed ▪ Minimal wait time	▪ Accessible locations ▪ Fast charging speed, network uptime ▪ Easy search functionality ▪ Quick billing ▪ Ancillary services

• Battery-as-a-service (BaaS) gaining prevalence to reduce upfront EV acquisition cost

BaaS is gaining traction, as it can reduce charging wait times along with high upfront cost of EVs. It helps consumers lease batteries separately, eliminating the need to purchase the battery upfront along with the vehicle. The model allows users to swap the battery in swapping stations for a recharged battery every time the battery gets discharged.

BaaS is driving prevalence in e-buses since the model can drastically reduce the initial costs of EVs by up to 50 per cent. The battery for a 9m electric bus costs between INR0.5-0.55 crore, while the entire bus costs between INR0.12-0.13 crores[3]. For OEMs, this will help match prices with fossil fuel counterparts, making it a viable option for whom prices have been a major concern.

While there are numerous advantages to using BaaS as a model for EV adoption, there are certain inherent problems like requirements of EVs are currently not standardised. EV and battery manufacturers throughout the world have been adopting varying standards for the design of their products based on criteria such as financial resources, technological expertise and research and development skills and this has a trickle-down effect on battery requirements. Given the multitude of battery and EV manufacturers, high entry barriers are expected for EV charging solutions.

1. China-plus-one strategy puts India at a vantage position: Rajeev Chandrasekhar", The Hindu, 17 November 2022, as accessed on 20 March 2023
2. "Handbook of electric vehicle charging infrastructure implementation", NITI Aayog, 8 December 2021, as accessed on 20 March 2023
3. Battery-as-a-Service (BaaS): The Revolution Ahead, EBC Publishing Pvt. Ltd., 24 June 2022, as accessed on 20 March 2023

However, for the BaaS model to function more effectively, it will be crucial to have battery standardisation across EVs as well as interoperability, offering the ability to use the same battery in different types of EVs. To increase the potential of the BaaS model, a strong collaboration between all the players is critical, which could eventually help solve the issue of interoperability.

- **Leasing – a new model being adopted**

Driver partners are hesitant towards direct ownership of EVs, due to apprehensions around vehicle performance and financial constraints. Moreover, limited financing options in the market with only few NBFCs present in the market. Current financing has high Interest rates (23-25 per cent) are exorbitant and short tenure (two years).

Consumers are reluctant to purchase EVs due to several factors, including high cost of investment, apprehensions around performance, after-sales service, among others. Some of the factors restraining their purchase are listed below, and these continue to be the major factors around why consumers do not go for upfront purchase of an EV.

Fig 5.4 Factors that make leasing a preferable way for last mile aggregators to acquire EVs are as follows:

Asset Quality	High Upfront cost	Lack of ecosystem	Residual value
• **Lack of product focus for B2B needs** • **Lack of clarity around vehicle performance** (such as range, battery life, maintenance) resulting in lack of confidence amongst driver partners	• **High upfront cost differential** (approx. 40 per cent without subsidy) while TCO parity in the B2B segment with ICE counterparts	• Given the limited fleet and adoption of EVs till date, the ecosystem is currently at a nascent stage, owing to: – **Lack of standardisation** of charging infrastructure – **Absence of trained mechanics**/EV personnel	• The secondary market for EVs has not evolved, given the limited end of life providers for EVs: – **Lack of battery repurposing players**/options – **Limited technical awareness** to evaluate battery residual value

Consequently, leasing as an option helps eliminate these factors and hence is gaining preference among consumers. Leasing eliminates the pros of investing a dedicated amount to an asset, while offering the same benefits of owning an EV.

- The rise of EVs has created several economic opportunities throughout the value chain, particularly for technological players and charging infrastructure operators.
- In addition, the Indian government has launched a variety of initiatives and schemes to capitalise on the enormous opportunity given by the EV industry. Additionally, the China-plus-one diversification strategy is expected to boost domestic electronics and semiconductor production.
- Moreover, battery-as-a-service is expected to continue gaining traction as it could help reduce charging wait times and high initial cost of EVs.

6 Start-ups at the forefront of the disruption – from OEM to fintech to battery recycling

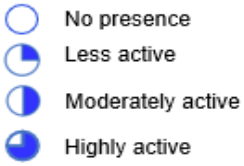
The traditional hegemony of auto OEMs is unlikely to provide them a clear "right to win" in the Indian EV industry. With a large technology component and ability to adapt to fast changing regulatory and customer needs being key to success, start-ups have the ability to disrupt the space occupied by large auto OEMs. In recent years, India's start-up ecosystem has grown exponentially, garnering attention from both traditional and non-traditional OEMs. Smaller EV OEM start-ups are competing against big industry players in the two-wheeler and three-wheeler spaces, where the volume is expected to see growth in the near future. Moreover, start-ups are gaining prevalence across various phases of the EV value chain in terms of providing technological tools and software, battery solutions, leasing, ride hailing, and charging infrastructure.

As of March 2022, the Indian EV industry hosts 592 start-ups[1] spanning across battery production, charging infrastructure and battery recycling. Indian start-ups are becoming increasingly prominent in the EV value chain, offering advanced technology solutions.

Fig 6.1 The EV Value chain – from OEMs to customer

Phase	OEMs	Fleet operators	Lessors	Energy solutions
Key activities	▪ Manufacturing EVs such as two-wheelers, three-wheelers, and buses ▪ Electric mobility solutions ▪ Electric motors ▪ Battery as a Service solution ▪ Vehicle maintenance services	▪ Logistics services ▪ Mobility services like – Ride hailing – Car rentals ▪ First and last mile connectivity ▪ Fleet management ▪ Shared micro-mobility service ▪ Vehicle tracking ▪ Payment collection	▪ Renting services ▪ Battery leasing ▪ Subscription of EVs ▪ Maintenance and repair services	▪ Battery packs ▪ Battery/cell manufacturing ▪ Battery swapping ▪ Energy storage solutions ▪ Smart energy delivery ecosystem ▪ Pay-as-you-go system for battery usage
Presence of start-ups				
Factors supporting/hindering entry	• Technical know-how and capabilities • Government policies and initiatives • Huge capital requirement in heavy vehicles	• Several small players with technological niche • Unavailability of comparable EV models in the commercial segment	• High upfront cost of EVs • New business model along with EVs	• New business model along with EVs • Technological know-how • Government policies and initiatives

Factors supporting growth
Factors hindering entry

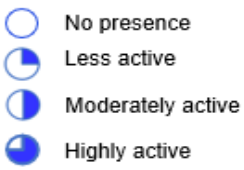


1. Unlocking India's electric mobility potential, Arthur D little, August 2022

Fig 6.2 The EV Value chain – supporting infrastructure

Phase	End of life solutions	Financing/insurance	Charging
Key activities	▪ End-to-end solutions for recycling and disposal ▪ E-waste management ▪ Battery disposal ▪ Battery recycling ▪ Battery second life management ▪ Assessment of residual value ▪ Vehicle refurbishment	▪ Financing services ▪ Insurance solutions – Insurtech – Digital insurance	▪ Providers of EV charging stations and equipment for private and public space ▪ AC (Alternating current) and DC (Direct current) charger ▪ Fast and slow charging solution ▪ Charge point operations ▪ Wireless charging ▪ Software platforms for charging networks
Presence of start-ups			
Factors supporting/hindering entry	• Several small players focusing on sustainability solutions • Progressive government regulations • Technological know-how	• Poor focus by traditional players • start-ups leveraging technology to overcome challenges of loan defaults and asset loss	• New business model along with EVs • Moderate investments • Easy to set up • Increasing demand for infrastructure • Government policies and initiatives

Factors supporting growth
Factors hindering entry



7 Future of mobility

EV is becoming a reality

The shift to EVs is no longer an uncertainty but only a question of when. Adoption levels are expected to see exponential growth in future with developing infrastructure, government incentives and the launch of new EV models.

- EV 3W and 2W are already in the consideration set of buyers while purchasing a new vehicle due to availability of comparable performance with ICE, low TCO over the life of vehicle and strong government subsidies
- EV buses to see continued adoption in intra-city public transport followed by inter-city transports with government's focus on decarbonising the public transport system
- Unavailability of affordable models, under-developed charging infrastructure along the highways are some hinderances for e-4W. However, with increased thrust by OEMs on EV development programme and improving charging infrastructure, EV transition in 4W private segment is expected to pick up soon.

Technology to play a crucial role

Technology is at the forefront of the EV revolution. The shift from ICE to EV has increased the electronics content from 16 per cent to 55 per cent in a vehicle with the addition of new features and controls. Many of these technologies are going to become standard offerings in the future and the addition of newer features/ development of new technology is going to be a continual process. Adoption of Advanced Driver Assistance Systems (ADAS), telematics is expected to intensify with the advent of EVs in the market. Outside the vehicle also, the automotive ecosystem will continue to transition with the support of technology in product development, sales support, servicing, charging infrastructure, financing, end of life ecosystem, among others.

Such a high proportion of technology in and out of the vehicle brings into play a diverse set of players that were not auto focused. For instance, software players, cloud and analytics platforms, telecom operators, infotainment providers, among others.

EVs beyond the traditional players

While EVs became part of strategic plan for the traditional players in the past few years, Indian start-up ecosystem has capitalised on the void at the early stages and now play a significant role in the EV ecosystem. Most of these start-ups are setting the pace for technological innovation in the EV ecosystem.

It will be critical to leverage the technical niche that these players offer, to utilise the full potential of the growing EV business. As adoption continues, many of these start-ups are expected to grow and take market share away from the traditional ICE players.

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