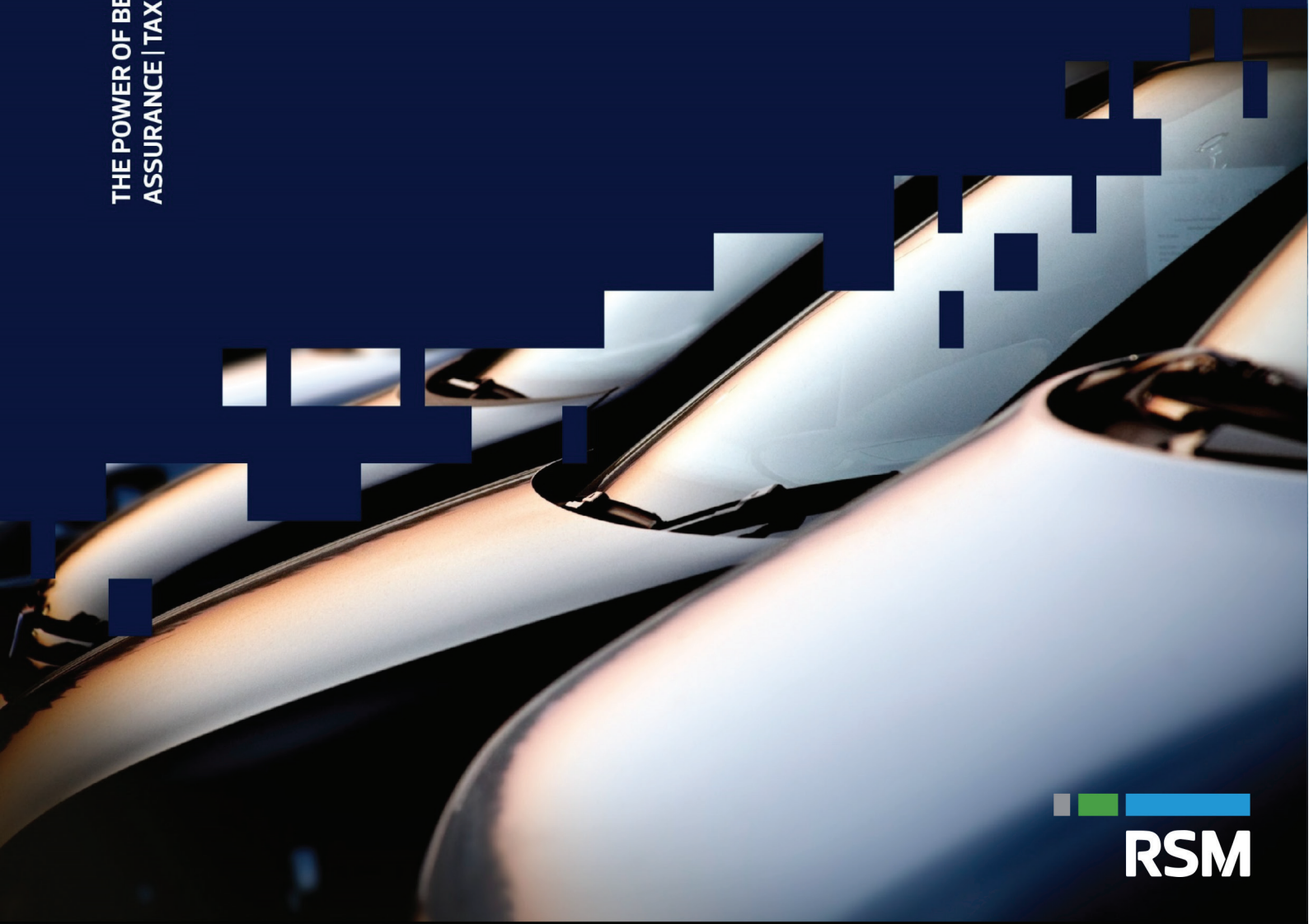
accelerate prosperity

Funded by the European Union

Electric Vehicle Landscape Study of Pakistan.

THE POWER OF BEING UNDERSTOOD
ASSURANCE | TAX | CONSULTING



RSM

EV Landscape Study of Pakistan

This report is being submitted to

Ms Rohma Labeeb
Country Director
Accelerate Prosperity (Pvt) Limited
5-A, Constitution Avenue, Sector F-5/1
Islamabad

By **RSM Avais Hyder Liaquat Nauman Chartered Accountants** (hereinafter referred as "**RSM Pakistan**") as per Section C of the contract with Accelerate Prosperity for **EV Landscape Study of Pakistan**

Authorized Representative

Syed Naveed Abbas
Partner – RSM Pakistan

RSM Pakistan – Islamabad
18 B/1, 1st Floor, Chohan Plaza,
Sector G-8 (Markaz),
Islamabad, Pakistan

Ph: +92 (51) 2340490- 93
Fax: +92 (51) 9334673

Email: naveed.abbas@rsmpakistan.pk
Web: www.rsmpakistan.pk

DISCLAIMER

The information and data presented in this report are based on the best available sources at the time of publication. However, the rapidly evolving nature of the electric vehicle industry means that some details may have changed since the referenced sources were published.

While every effort has been made to ensure the accuracy of the content, the authors and publishers do not guarantee the accuracy, completeness, or reliability of the information. The views and opinions expressed in referenced external sources do not necessarily reflect those of the authors or publishers.

This report is intended to provide a general overview and should not be relied upon as the sole basis for business decisions. Readers are advised to consult additional sources and industry experts for the most up-to-date information and to evaluate the suitability of any course of action in their specific circumstances.

This publication is produced with the financial support of the European Union. Its contents are the sole responsibility of Accelerate Prosperity and RSM, Pakistan and do not necessarily reflect the views of the European Union.

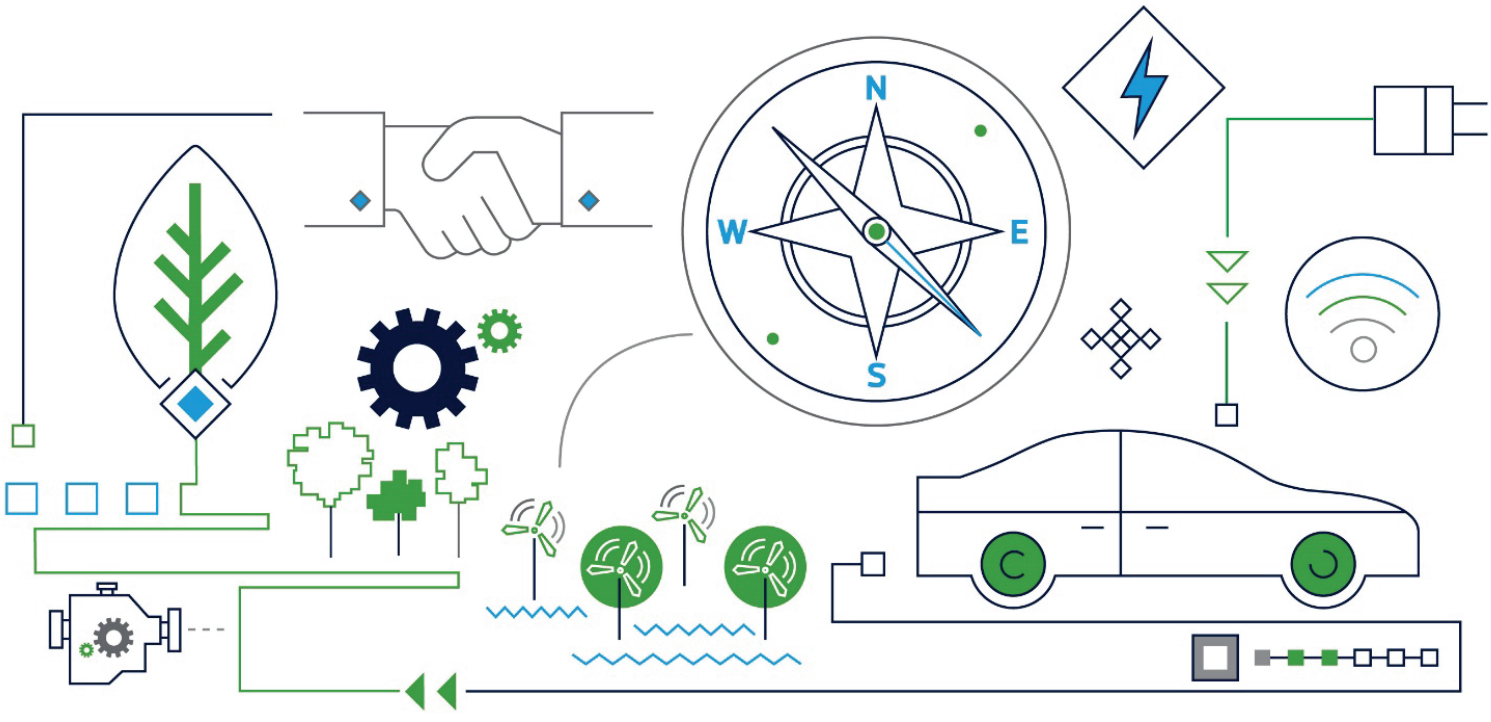


Table of Contents

DISCLAIMER

PRELUDE 1

REIMAGINING TRANSPORTATION 3
1.1 Setting the Context 4
1.2 EV Evolution 4
1.3 Mapping the EV Ecosystem 4
1.4 A Typical EV Design 5
1.5 EV Components 6
1.6 Charging Infrastructure 13
1.7 The EV Value Chain 13
1.8 The Green Aspect of EVs 16
1.9 Conclusion 18

GLOBAL EV LANDSCAPE 19
2.1 Evolution of the Global EV landscape 20
2.2 EV Global Market Segments 24
2.3 Charging Infrastructure 25
2.4 Latest Global Sales Trends 26
2.5 Future EV Sales Outlook 28
2.6 Key Global Players & Competition: 29
2.7 Financial and Affordability Aspects 32
2.8 Conclusion 36

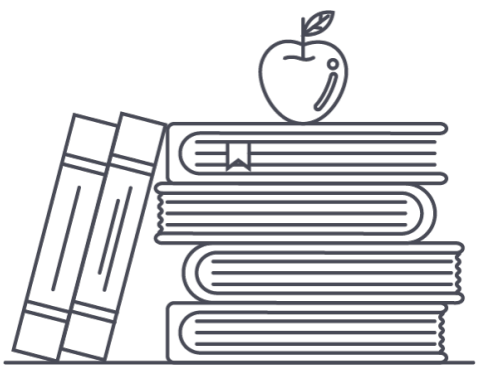
PAKISTAN EV LANDSCAPE 37
3.1 Pakistan's Automobile Sector 38
3.2 The Electric Vehicle (EV) Segment of Pakistan 42
3.3 EV Charging Infrastructure 44
3.4 EV Parts Supply Chains 45
3.5 EV Policy & Regulation 46
3.6 Total Cost of Ownership (TCO) 47
3.7 Conclusion 50

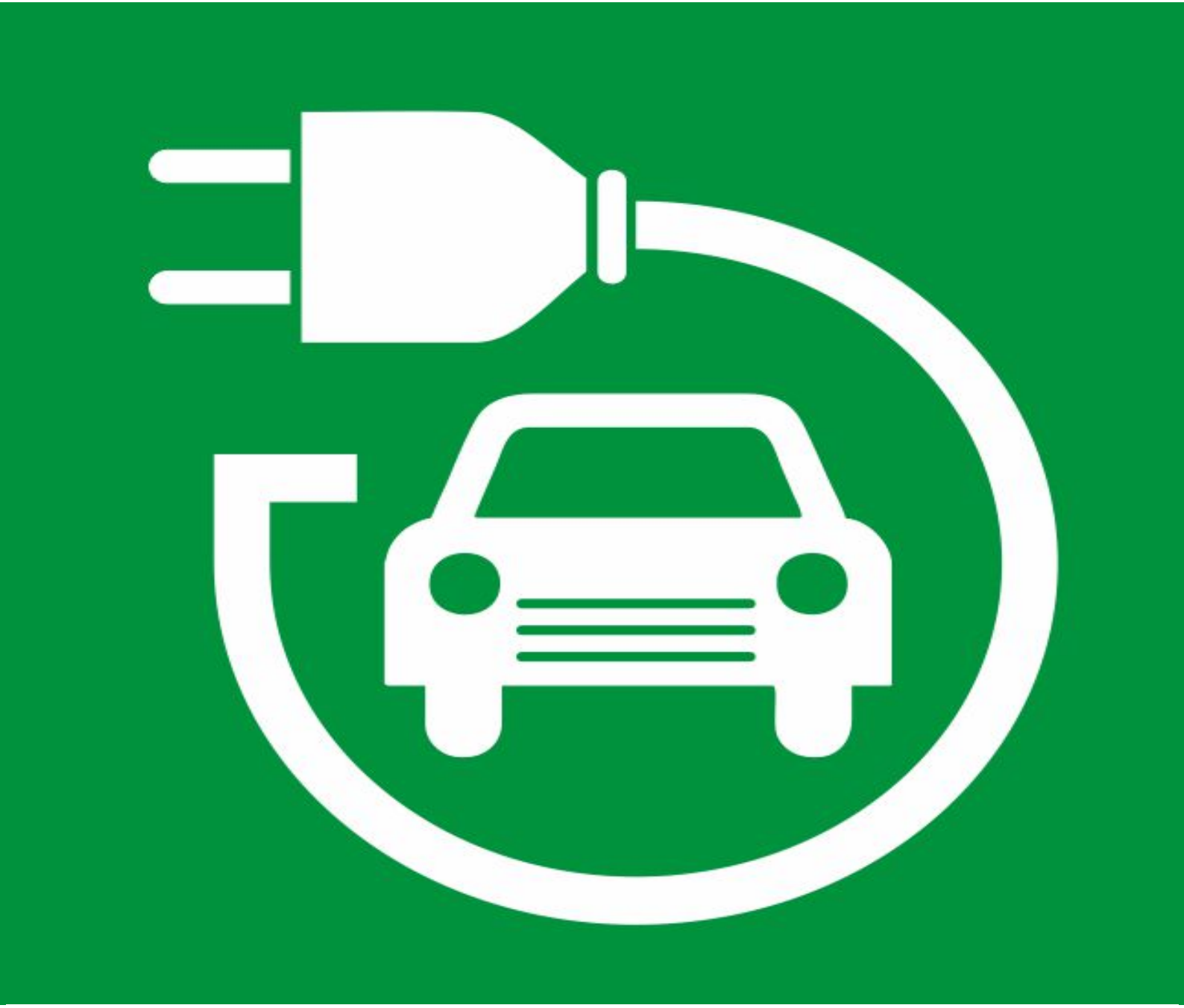
PERICULA EV 51
4.1 Government Regulations and Policies 52
4.2 Consumer Risks & Challenges 54

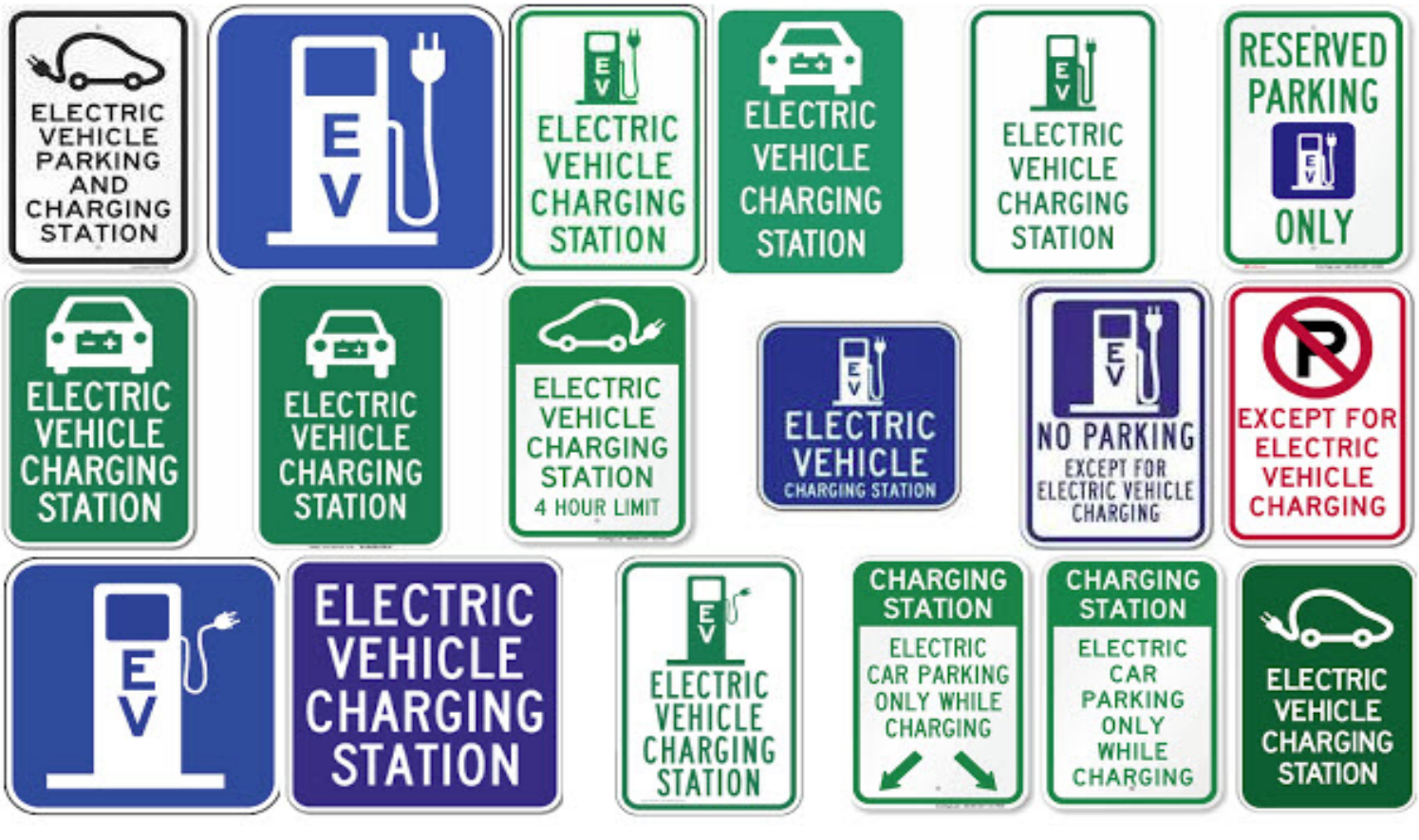
EV FINANCING 57
5.1 EV Financing – International 58
5.2 Geographical Concentration of EV Investments 60
5.3 National Financing Landscape 61

RECOMMENDATIONS FOR EMBRACING CHANGE 63
6.1 Recommendations for the Regulators and Government 64
6.2 Recommendations for AP 66

ANNEXURE 71
Annex 01: Commonly Used Charging Connectors from IEC 62196 72
Annex 2: List of 2-Wheelers and 3-Wheelers 73
Annex 3: Global 2-Wheelers, and 3-Wheelers 76
Annex 04: Due Diligence Findings of Selected Companies 77






ELECTRIC VEHICLE PARKING AND CHARGING STATION
EV
ELECTRIC VEHICLE CHARGING STATION
ELECTRIC VEHICLE CHARGING STATION
ELECTRIC VEHICLE CHARGING STATION
RESERVED PARKING
EV
ONLY
ELECTRIC VEHICLE CHARGING STATION
ELECTRIC VEHICLE CHARGING STATION
ELECTRIC VEHICLE CHARGING STATION
4 HOUR LIMIT
EV
ELECTRIC VEHICLE
CHARGING STATION
EV
NO PARKING
EXCEPT FOR ELECTRIC VEHICLE CHARGING
P
EXCEPT FOR ELECTRIC VEHICLE CHARGING
EV
ELECTRIC VEHICLE CHARGING STATION
EV
ELECTRIC VEHICLE CHARGING STATION
CHARGING STATION
ELECTRIC CAR PARKING ONLY WHILE CHARGING
CHARGING STATION
ELECTRIC CAR PARKING ONLY WHILE CHARGING
ELECTRIC VEHICLE CHARGING STATION

PRELUDE

Introduction

The transition to electric vehicles (EVs) represents a significant shift in the global automotive industry, driven by the urgent need to reduce greenhouse gas emissions and combat climate change. As nations worldwide strive to adopt sustainable transportation solutions, Pakistan stands at a pivotal juncture, with its unique set of challenges and opportunities in the EV sector.

Purpose of the Study

The purpose of the study is to assist Accelerate Prosperity (AP) in making investment decisions within Pakistan's EV landscape. AP is a global initiative of the Aga Khan Development Network (AKDN) in Central and South Asia, which follows guidance from the Aga Khan Foundation (AKF) Board to develop more formal structures to catalyze enterprises within AKDN's main area development programs, where economic opportunities remain insufficient. AP's goal is to promote local businesses and startups in achieving scale through subsidized financing. It is expected that by the end of the study, AP team will have sufficient understanding of the market to be able to make informed investment decisions within the EV market.

This report aims to provide a comprehensive analysis of the EV landscape in Pakistan, examining the current state, potential growth, and the strategic measures necessary to foster an environment conducive to EV adoption. By exploring the technological, economic, and policy dimensions, the study seeks to offer actionable insights for all stakeholders, including policymakers, industry players, consumers and especially investors like AP.

Importance of the Study

Understanding the EV landscape in Pakistan is crucial for several reasons:

- **Environmental Impact**: Pakistan is ranked globally amongst countries with worst air quality. Vehicular tail-pipe emissions are the leading cause of air pollution in the country and the two- and the three-wheeler segments are estimated to be responsible for 41% of the emissions from the road-transportation sector. EVs have the potential to significantly reduce carbon emissions, contributing to cleaner air and a healthier environment.
- **Economic Growth**: Pakistan is facing a severe economic crisis with dwindling foreign exchange reserves, notable trade deficit, and rising current account deficit. The adoption of EVs can spur economic development by creating new industries, jobs, and investment opportunities.
- **Energy Security**: Pakistan's road-transportation sector is responsible for about 60% of the total petroleum consumption in the country and import of petroleum accounts for 30%

of the total national import bill. Reducing the reliance on imported fossil fuels can enhance national energy security.

- **Technological Advancement**: Embracing EVs can drive innovation and technological progress in the automotive sector and related industries.

Scope of the Report

The report covers various aspects of the EV landscape, including:

- **Evolution of the EV landscape**: The adoption, trajectory and future of the EV landscape, value chain analysis of the EV sector, EV design, components and technology.
- **Global EV landscape**: Key global market segments, global technology advancement and its future, charging infrastructure growth and key global players and stakeholders.
- **Pakistan's EV landscape**: Key domestic market segments, regulatory framework for EVs, main stakeholders and key players in the EV ecosystem including domestic businesses, current state of the domestic charging infrastructure and its future, a comparison of local and global manufacturing.
- **Financing activity in EV space**: Global and domestic funding, merger and acquisition activity in the domestic and global market space.
- **Key Risks and Challenges of EV Adoption**: Market, regulatory, commercial and financial risks.
- **Recommendations for Policymakers and Investors:** Key recommendations for AP to manage its investments in the local EV space and recommendations for regulators.

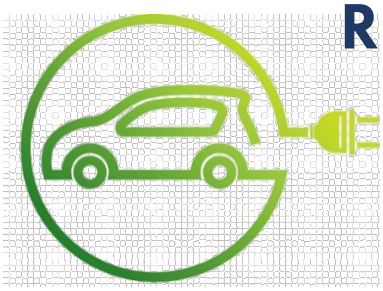
Construct

The study employs a multi-faceted approach, utilizing qualitative and quantitative research methods. Data is collected from a range of sources, including government publications, industry reports, expert interviews, and market surveys. This comprehensive methodology aims to enhance the reliability and validity of the findings and recommendations presented in the report.

Conclusion

As Pakistan navigates its path towards sustainable transportation, the insights provided in this report aim to inform and guide the stakeholders involved in shaping the future of the EV landscape. By understanding the current scenario and the potential for growth, Pakistan can take strategic steps to become a key player in the global shift towards electric mobility.

Section 01



REIMAGINING TRANSPORTATION

Electric Vehicles (EVs) have emerged as a transformative force in the automotive industry in recent times, offering a sustainable alternative to traditional internal combustion engine (ICE) vehicles. This chapter aims to provide a comprehensive overview of EVs, covering their historical backdrop, evolution, technology and the ecosystem that supports their growth.

EVs do not have conventional engines but instead, are driven solely by one or more electric motors powered by energy stored in batteries. The batteries are charged by plugging the vehicle into an electric power source and may also be charged through regenerative braking[1]. EVs cost less to operate, so the higher initial vehicle cost can be offset over the lifetime of the vehicle. That is because electric transmission systems or drivetrains are much more efficient than Internal Combustion Engine (ICE) counterparts, and electricity is much cheaper than gasoline or diesel fuel.

All-electric vehicles produce no tailpipe emissions, although there are Indirect "lifecycle" emissions associated with the electricity production. However, all-electric vehicles typically have shorter driving ranges per charge than conventional vehicles have per tank of gasoline. EVs take many forms such as two-wheelers, three-wheelers, passenger vehicles, trucks, buses, and use different technologies, which will be discussed later in the report.

The EV ecosystem encompasses all elements involved in the supply chain, production, distribution, sale, and use of electric vehicles. This includes components such as charging infrastructure, battery technology, vehicle manufacturers, government policies, energy providers, and consumer behavior. The EV ecosystem is interconnected, with advancements in one area often influencing developments in others. It represents a holistic approach to transitioning to electric mobility, addressing challenges and opportunities across the entire value chain.

[1] Regenerative braking uses the kinetic energy of the car in motion and converts it into the electrical energy which charges the vehicle's battery.

1.1 Setting the Context

The concept of electric vehicles is not new; in fact, early experiments with electric propulsion date back to the 19th century. However, it was not until recent decades that advancements in battery technology, concerns over climate change, and the push for energy independence propelled EVs into the mainstream.

Historically, EVs faced challenges such as limited range, high costs, and lack of infrastructure. However, technological innovations, coupled with environmental awareness and government incentives, have spurred a resurgence in EV adoption. Today, EVs represent a significant opportunity to reduce greenhouse gas emissions and dependence on fossil fuels.

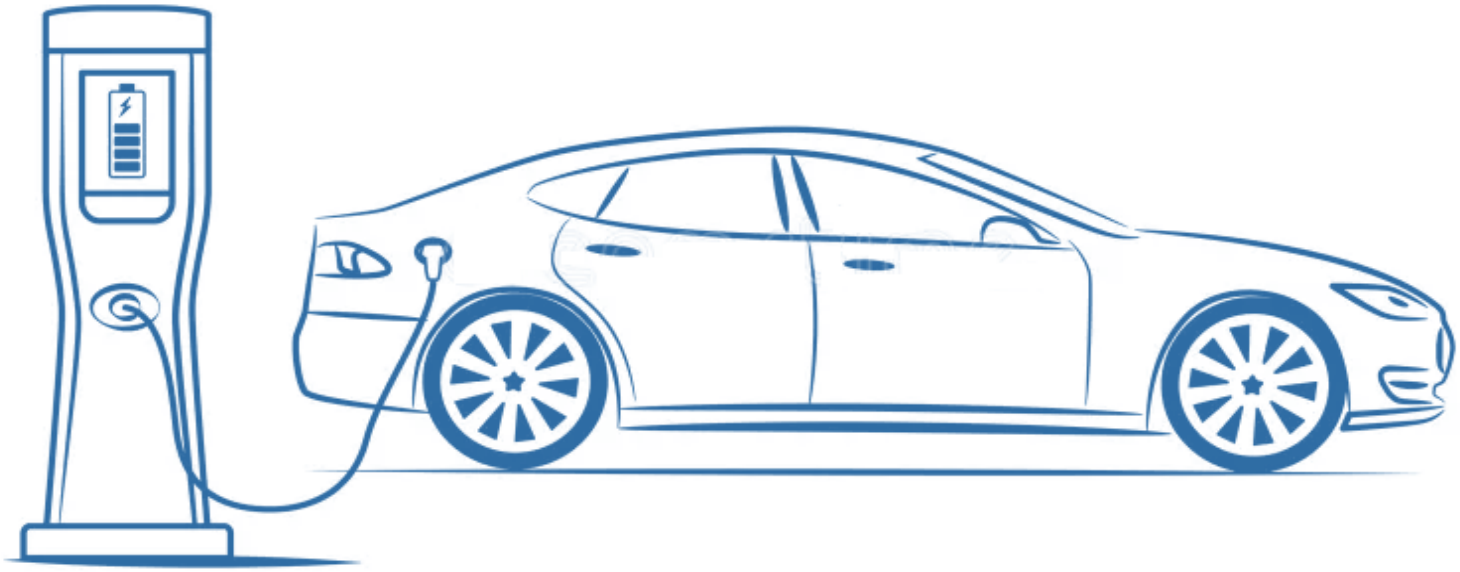
Tesla's introduction of the Model S in 2012 marked a turning point, demonstrating that EVs could be desirable, high-performance vehicles. Since then, major automakers have entered the EV market, offering a wide range of models to suit various preferences and budgets. From compact city cars to luxury SUVs, there is now an EV for almost every need.

1.2 EV Evolution

The evolution of electric vehicles has been marked by significant milestones and breakthroughs. Early electric cars were limited by the capacity and performance of lead-acid batteries. However, the development of lithium-ion batteries revolutionized the industry, enabling longer range and faster charging times. Additionally, advancements in autonomous driving technology, connectivity, and energy management systems are further reshaping the evolution of EVs. These innovations promise to make electric vehicles safer, more convenient, and more efficient than ever before.

1.3 Mapping the EV Ecosystem

The success of electric vehicles relies on a supportive ecosystem that encompasses various stakeholders and infrastructure components. Electric vehicles represent a paradigm shift in transportation, offering a cleaner, more sustainable alternative to conventional cars. The journey from early experiments to widespread adoption has been marked by innovation, collaboration, and perseverance. As the EV ecosystem continues to evolve, its potential to reshape the automotive industry and reduce environmental impact is greater than ever before. Key elements of the EV ecosystem include:



Vehicle Manufacturing

- Automakers play a vital role in driving innovation and producing EVs that meet consumer demands. The industry is seeing a shift towards electric models, with many manufacturers pledging to electrify their entire fleets in the coming years.

Charging Infrastructure

- A robust network of charging stations is essential for widespread EV adoption. This includes home charging solutions, workplace charging stations, and public charging networks along highways and in urban areas. Battery swap business models is another variation in commercial charging.

Battery Technology

- Advances in battery technology are crucial for improving the range, performance, and longevity of EVs. Research efforts focus on increasing energy density, reducing costs, and enhancing safety.

Consumers

- Educating consumers about the benefits of electric vehicles and addressing concerns about range, charging, and cost are essential for increasing adoption rates. Test drive events, incentives, and marketing campaigns can help raise awareness and dispel myths about EVs.

Energy Supply

- Collaboration between automakers and energy providers is essential for integrating EVs into the electricity grid efficiently. Smart charging solutions and vehicle-to-grid technology enable EVs to store and discharge energy, contributing to grid stability and renewable energy integration.

Public Sector

- Government incentives, regulations, and subsidies can significantly influence the adoption of electric vehicles. Initiatives such as tax credits, rebates, and emissions standards encourage consumers to choose EVs and support the development of charging infrastructure.

1.4 A Typical EV Design

The interior and exterior of an EV varies significantly in terms of the technology and aesthetics. The inside of an EV has seen the addition of new technological components in the last few years, such as battery management system (BMS), motor controller, touch dashboard, battery technology, motor technology and telematics.

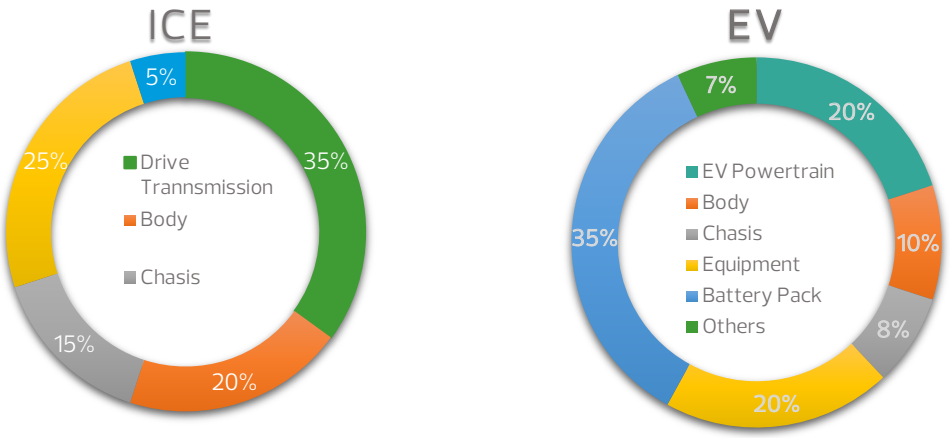
The heart of an EV, the electric powertrain, consists of three main parts: a battery pack that stores electrical power, a motor that converts electrical power into mechanical energy, and a controller that interfaces between battery and motor to control speed and acceleration. Together these parts integrate to provide a smooth EV experience to users.

As discussed, the transition from ICE to EVs has seen a transformative change with major advancements both in the use of technology and software. Following are some of the major developments witnessed inside an EV as compared to their ICE predecessors:

- The engine has been replaced by battery with a technology addition of BMS
- Transmission has been replaced by motor and controllers
- Normal analog screens have been replaced by digital touch screens
- Increased number of ECUs (Electronic Control Units) with advanced software programming

As per a report[2] by KPMG India, a graphical comparison of EVs and ICE vehicles in terms of their mechanical versus electronic composition is presented below:

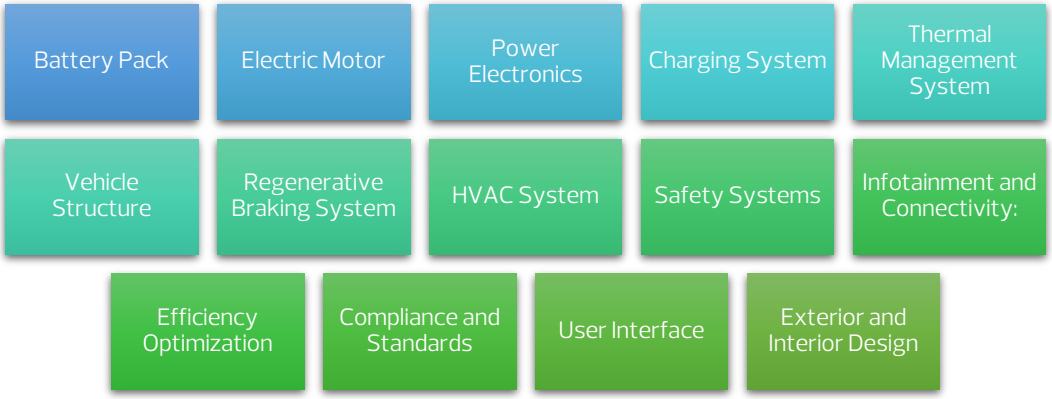
[2] Technology at the Forefront of Electric Vehicles



*The electronics content has increased from 16% in ICE vehicles to 55% in EVs.

1.5 EV Components

A typical EV design encompasses several key components to ensure efficiency, safety, and functionality. These components collectively contribute to the overall design of an EV, balancing performance, efficiency, safety, and user experience. The illustration below depicts a general design of an EV.



1.5.1 Major Components

Major components of an EV design are discussed below.

Batteries

A battery is a container that consists one or more cells in which chemical energy is converted into electricity and is used to store power. There are three primary battery types that are used for electric vehicles. These are Lead-Acid, Nickel Metal Hydride (NIMH), and Lithium-Ion batteries.

a) Lead – Acid Batteries

Lead-Acid batteries are known for their long service life. They are usually inexpensive to purchase. At the same time, they are extremely durable, reliable and do not require much maintenance. A weak point of lead batteries, however, is their sensitivity to deep discharge, meaning that the battery can be damaged. The optimum operating temperature for the lead-acid battery is 25°C (77°F). As a guideline, every 8°C (15°F) rise in temperature will cut the battery life in

half. And lead-acid batteries drop in capacity by about 20% in normal to freezing weather, and down to about 50% in temperatures that reach about -30°C (-22 °F).

b) Nickel-Metal Hydride Batteries (NIMH)

Nickel-Metal Hydride batteries offer reasonable specific energy and power capabilities. These batteries have a much longer life cycle than lead-acid batteries and are safe and abuse-tolerant. These batteries have been widely used in vehicles. The main challenges with these batteries are their high cost, heavier weight and higher self-discharge and heat generation at high external temperatures, and the need to control hydrogen loss. The performance of NIMH batteries is strongly dependent on the temperature that they are exposed to. At temperatures below -20°C, the capacity of these batteries significantly declines.

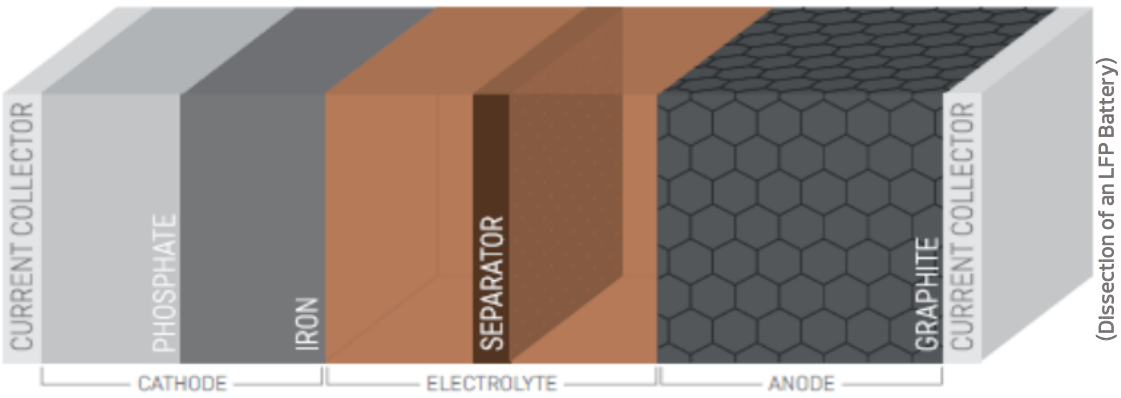
c) Lithium-Ion Batteries

The cost of Lithium-ion batteries is slightly higher than other battery types, but they give a lot in return. Lithium-ion batteries have a constant power output. There is very little loss of performance within the lifecycle of the battery and they perform well under high temperature situations. Another advantage of lithium-ion batteries is that they are able to recharge very quickly, and have a high power to weight ratio, meaning that they are lighter than most batteries and are therefore, ideal for mobile solutions.

Lithium-ion batteries come in several types, however, the most common types used by EVs are **Lithium Iron Phosphate** (LFP) and **Nickel Manganese Cobalt** (NMC). Because both LFP and NMC batteries are members of the lithium-ion battery family, they have many similarities. For both batteries, the displacement of lithium is the main chemical reaction within the battery, both contain an Anode, Separator, and Cathode and the chemical composition of the Separator and Anode stay the same. The difference is mainly in the cathode layer with the LFP battery containing iron and phosphate cathode composition, whereas the NMC batteries contain a multi-layered cathode made of nickel, cobalt, and manganese.

The thermal stability of LFP is the best among lithium-ion batteries. The peak value of electric heating is greater than 350°C after which its internal chemical composition begins to decompose. The thermal stability of NMC battery is poor, and the thermal decomposition temperature is 200-300°C, Therefore, under high temperature conditions, the safety of LFP is relatively high.
At minus 20 °C, NMC battery can release 70.14% of the capacity, while LFP battery can only release 54.94% of the capacity.

LFP (Lithium Iron Phosphate)



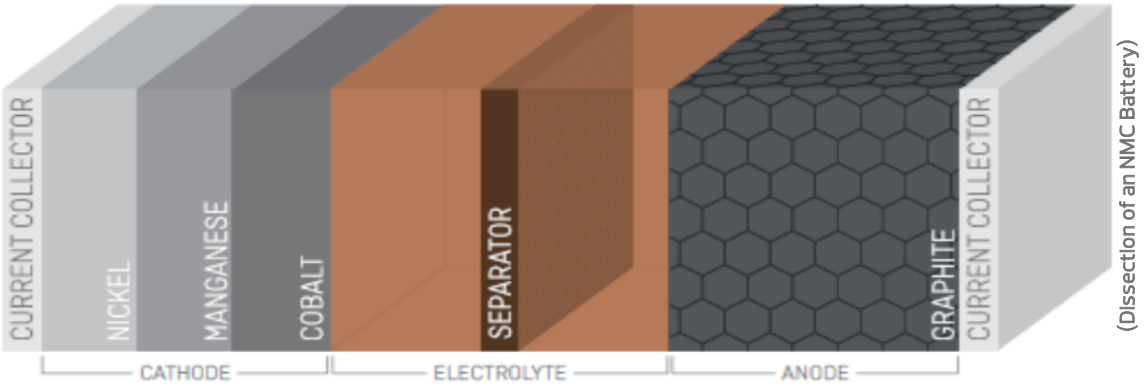
(Dissection of an LFP Battery)

LFP is short for LiFePO, also known as the chemical indication for lithium, iron and phosphate. This chemical compound forms the basis of the cathode. One of the most highlighted features of LFP batteries is the non-usage of cobalt – No cobalt or nickel is needed in the development of LFP batteries, and the materials that are used in this type of battery are comparatively common, safe, and easy to obtain.

Cobalt and nickel, on the other hand, are scarce and damaging to the environment since their mining pollutes water, air, and soil. Furthermore, they can lead to health issues for those who get in contact with these materials. A second important factor of an LFP battery is that the combination of raw materials used in this battery are very safe and stable. Even at high external temperatures, or when damage is done to the battery, this type of battery remains stable and will not catch fire. The third feature of LFP is its long life and durability. LFP batteries live up to 5000 full cycles until end of life, which is defined at 80% capacity.

As also mentioned earlier, LFP batteries can operate effectively across a broad temperature range, from -20°C to 60°C. LFP batteries may however experience reduced capacity (performing at around 70% capacity) and output in cold temperatures as the cold temperature can slow down the chemical reaction within the battery, limiting its performance. However, this effect is temporary and reversible, and the battery will recover as temperature rises.

NMC (Nickel Manganese Cobalt)



(Dissection of an NMC Battery)

NMC is also known as the chemical indication for nickel, manganese and cobalt. This chemical compound also forms the basis of the cathode. Nickel is known for its high specific energy and the manganese improves the life span. When combined, all three metals produce a cathode with a high energy density.

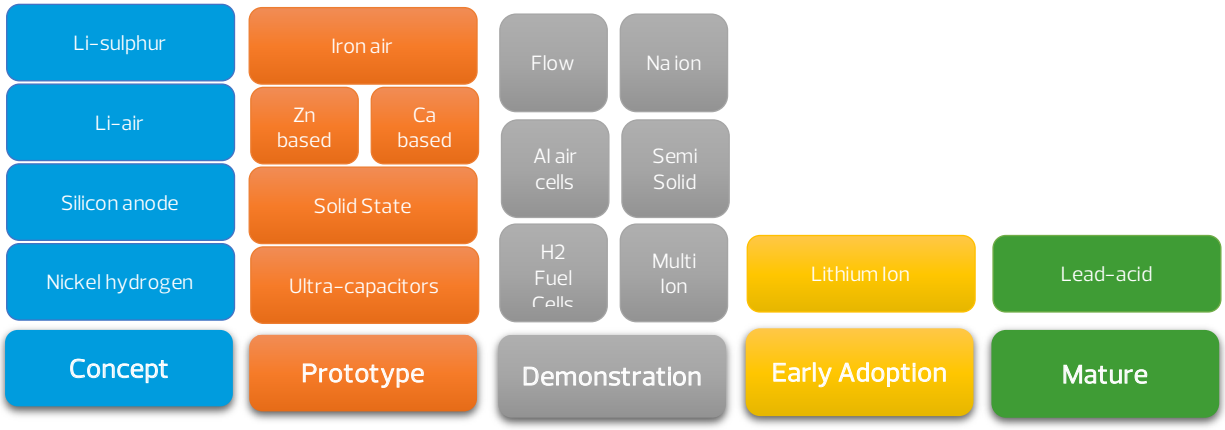
At the current stage, the energy density of NMC batteries is higher than that of LFP batteries. The energy density of a battery pack is also referred to as embodied energy. Energy density is the amount of energy a battery holds relative to its weight. A higher energy density is preferred because a smaller high-power battery can provide a higher output. As a result of this, the vehicle is lighter and therefore has a longer range, or can be equipped with lesser battery capacity for the same range.

Where LFP has a typical lifecycle of up to 5000 cycles, an NMC battery has an expected cycle life of about 2000–2500 cycles, but degradation sets in quickly and the full power is lost soon after its first use. As mentioned before, the chemical compound of an NMC battery consists of nickel and cobalt. Besides the fact that these are highly damaging to the environment, the composition of these raw materials is also highly sensitive. Meaning that if serious damage is done to the batteries, the chemical reaction that will occur in the battery will lead to an instant thermal runaway which causes smoke and fire.

1.5.2 Future of Batteries

Advanced Chemistry Cell (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 also making efforts to reduce the cobalt content from batteries due to its questionable mining practices, price volatility, geographical concentration, and the use of child labor in mining.

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 ACCs in the demonstration phase whereas lithium ion and lead acid have reached the early adoption and mature stages respectively. There has been a lot of interest in hydrogen cell chemistries in recent times, with the Japanese especially bullish on this technology. For example, an Indian company, Cochin Shipyard recently commissioned the country's first hydrogen fuel cell-based ferry with a capacity of 50 passengers, however, the usefulness, economics, safety and comparisons with other technologies is still under study, trial and early adoption.



Source: KPMG's Technology at the Forefront of Electric Vehicles Report

1.5.3 Motor

For EVs, the motor and controller are the vehicle's muscle and brain. These work together to ensure that EVs function efficiently and accurately.

The motor is where electromagnetism converts electricity into mechanical rotation. When a driver steps on the accelerator, electricity flows from the battery pack into a typical asynchronous motor. A coiled wire inside, called a stator, creates a rotating magnetic field, which causes the rotor to run, subsequently turning the car's gears and ultimately moving the wheels.

The controller consists of multiple power electronics and micro-computing elements. With its ability to process commands, calculate the energy needed and modify the energy flow from the battery, the controller can precisely regulate the EV's speed and direction. 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.

In general, there are two mainstream types of electric motors in EVs—asynchronous motors (induction motors) and synchronous motors. For an asynchronous motor, the rotor is pulled by a stator-created rotating magnetic field, thus it always turns slower than the stator field. For a synchronous motor, the rotor itself, often with ferromagnetic rare earth metals, generates a magnetic field that moves at the same speed as the stator. A synchronous motor is not self-starting, whereas an asynchronous motor can be self-started. An additional winding called damper winding provides the starting torque. An external DC excitation is required for the synchronous motor to start; however, an asynchronous motor does not require any external excitation to run. While synchronous motors are mostly used in urban-driving EVs, like the Nissan Leaf, for their efficiency at low speeds, asynchronous motors can be found in high-performance EVs such as the Tesla Model S.

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 permanent magnets as their key sub component, which uses rare metal concentrated in China. Dependence on rare earth metals can also be reduced through developing improved low-cost rare earth-free magnets and the development of the "magnet-less synchronous reluctance motors (SynRM)". In Pakistan, permanent magnet DC motors (1-1.5kW) are being used for 2-wheelers and AC Induction motors (3-5kW) are being used in 3-wheelers[3]. A comparison table of major motors in EVs is presented below:

Characteristic	DC Series	BLDC	PMSM	SynRM	AC Induction
Components	Permanent magnets constitute the major cost	Permanent magnets constitute the major cost	Permanent magnets constitute the major cost	Copper and steel constitute the major cost. Magnets are not present.	Copper and steel constitute the major cost. Magnets are not present.
Noise Level	High	Moderate	Low	High	Low
Manufacturing Cost	Moderate	Moderate	High	Low	Low
Efficiency	Low	Moderate	High	High	High

[3] Indigenization of EV value chain in Pakistan for two and three wheelers, 2024- LUMS

Advantages	Easy speed control, can withstand sudden increase in load	Maintenance free, high starting torque, satisfactory efficiency	High power density and high efficiency,	High power density, higher efficiency than induction motors	High efficiency, lower cost
Disadvantages	High maintenance due to brushes and commutators	High cost due to permanent magnets, overloading motor beyond a certain limit reduces the life of magnets	Costlier than BLDC	Costlier, less repairing expertise	Low starting torque, requires complex inverter circuit and control of the motor is difficult.
Usage / Application	Various uses including railways	Low and city speed, used by various electric bicycle and 3W EVs	Most hybrid and EV manufacturers use of 2W, cars, buses use these.	Currently a developing technology as an alternative to PMSM motors to counter the increasing usage of magnets.	EVs like Tesla S

Source: KPMG's Technology at the forefront of electric vehicles Report

1.5.4 Power Electronics

The power electronics manage the flow of electric energy through DC-AC inverters and DC-DC convertors for driving motors, controlling frequency, voltage and amplitude of the output to manage motor's speed and torque and stepping down voltage etc.

1.5.5 Battery Management System (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. This system is integrated into the battery pack to ensure optimal health and performance of each battery cell and pack.

The BMS monitors individual cells in the battery pack. It then calculates how much current can safely go in (charge) and come out (discharge) without damaging the battery. The current limits prevent the source (usually a battery charger) and the load (such as an inverter) from overdrawing or overcharging the battery.

This protects the battery pack from cell voltages getting too high or low, which helps increase the battery's longevity. As mentioned earlier, each cell in the battery pack needs to be balanced. The BMS balances the charge across the cells to keep each cell functioning at maximum capacity. As soon as the BMS detects any unsafe conditions, it immediately shuts the battery down, to protect the battery and user. The BMS also provides a lot of data that can be used for alternative purposes. For example, predictive maintenance can be done when the data indicates that issues may occur in the future. The functions of a BMS include:

- Over discharge protection: This prevents the battery from being discharged below a certain safe level.
- Short circuit protection: This protects the battery against short circuits between cells or between an electrode and the ground.

- 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.
- Cell balancing: This ensures each cell in the battery pack is equally charged and prevents damage to the cells and uneven charging.
- Current protection: This protects the battery against excessive charge or discharge currents.
- Overcharge protection: This prevents the battery from overcharging, which helps minimize or prevent damage.

1.5.6 Motor Controller

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. The motor controller is responsible for:

- 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

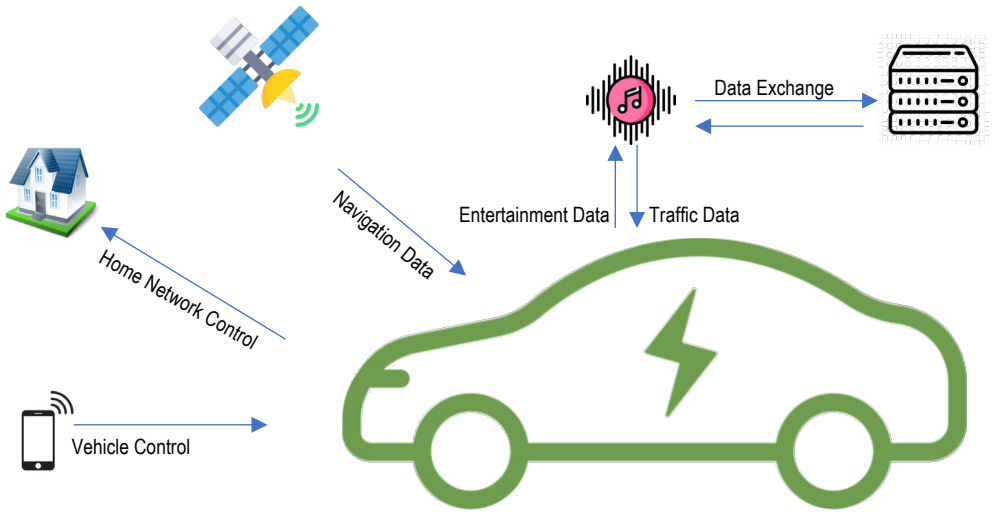
1.5.7 Advanced Telematics and Internet of Things (IoT)

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 Over-The-Air (OTA) updates.

EV Telmatics Overview



1.6 Charging Infrastructure

Although there are a number of different charging standards developed for the charging connector, a select number of them have become commonplace in recent years. It is important to note that power from the electrical grid is transmitted using AC electricity, whereas EV batteries are charged using DC power. This difference necessitates the conversion of electricity from AC to DC power at some point in the charging process. Depending on the type of charging, the electricity from the grid is converted from AC to DC at different stages. With Level 2 charging i.e., higher voltage, faster charging, this happens inside the vehicle when the vehicle's internal power converter converts AC electricity to DC. With DCFC (Direct Current Fast Charging), a power converter inside the charger converts AC electricity into DC electricity before being delivered directly to the vehicle.

1.6.1 Charging levels

EV charging is generally bifurcated into three levels globally:

a) Level 1 Charging

Level 1 EV charging requires a single-phase 230V AC connection, and it is considered the slowest AC charging option. Since the power rate for AC Level 1 EV chargers goes from 1.8kW up to 2.4kW, charging with a Level 1 EV charger can be done over regular home wiring as long as there are no other high-demand appliances connected to the circuit.

b) Level 2 Charging

Level 2 EV charging requires a single-phase 230V connection for homes or a three-phase 400VAC connection for residential and commercial ones. Charging capacity for Level 2 chargers varies from 3.6kW up to 9.6kW, while high-capacity residential and commercial applications go as high as 22kW. Residential and commercial Level 2 EV charging requires dedicated electrical wiring to operate. Most EV chargers that come along EV 4-wheelers passenger cars are level 2 models.

c) Level 3 Charging

Level 3 EV charging features a complex electrical infrastructure to convert three-phase AC power to DC directly at the charging station. The power rate for a DCFC stall goes from 25kW up to 350kW and it charges extremely fast. Level 3 or DC Fast Charging stations are highly expensive, which is why they are almost exclusively used in public charging stations. Almost no homes will ever have this as it is very costly (presently around $50k-$100k to install) and electrical infrastructure at homes will not be able to withstand the high voltage of Level 3 chargers.

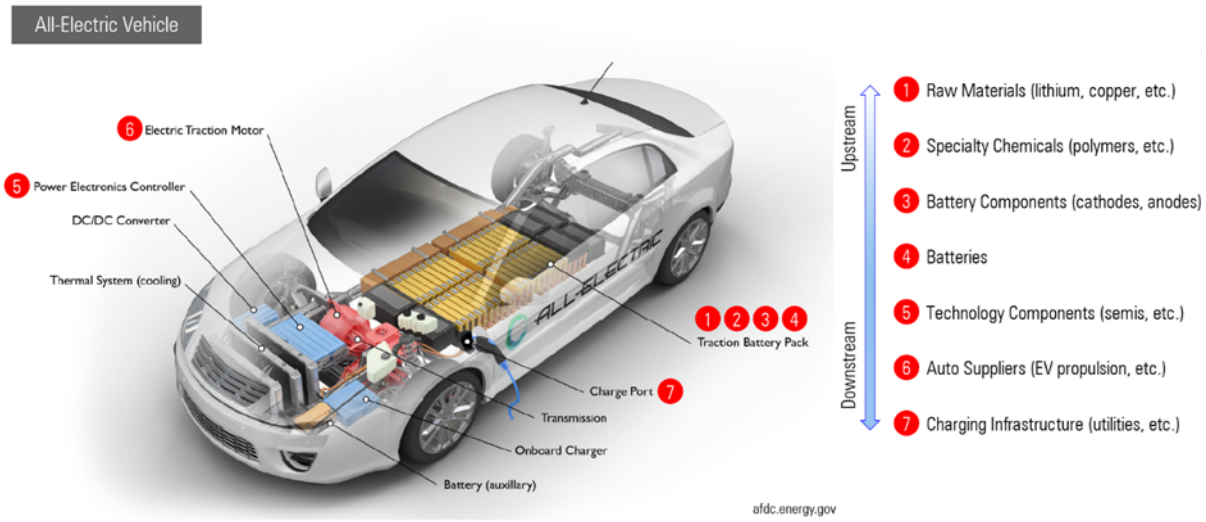
AC or DC power may be delivered to the vehicle using different charging connectors, the most common configurations are provided under Annex 01.

1.7 The EV Value Chain

As the EV performance is highly dependent on the capacity of energy storage and efficiency of electricity conversion, the EV value chain is centered around the electric powertrain.

The manufacturing of EVs starts from upstream companies supplying raw materials such as metals that can be used in the production of battery cells, moves to the midstream, consisting of EV parts and components suppliers that produce electric powertrain and other non-power components, and then completes the process at EV automakers who assemble the final vehicles

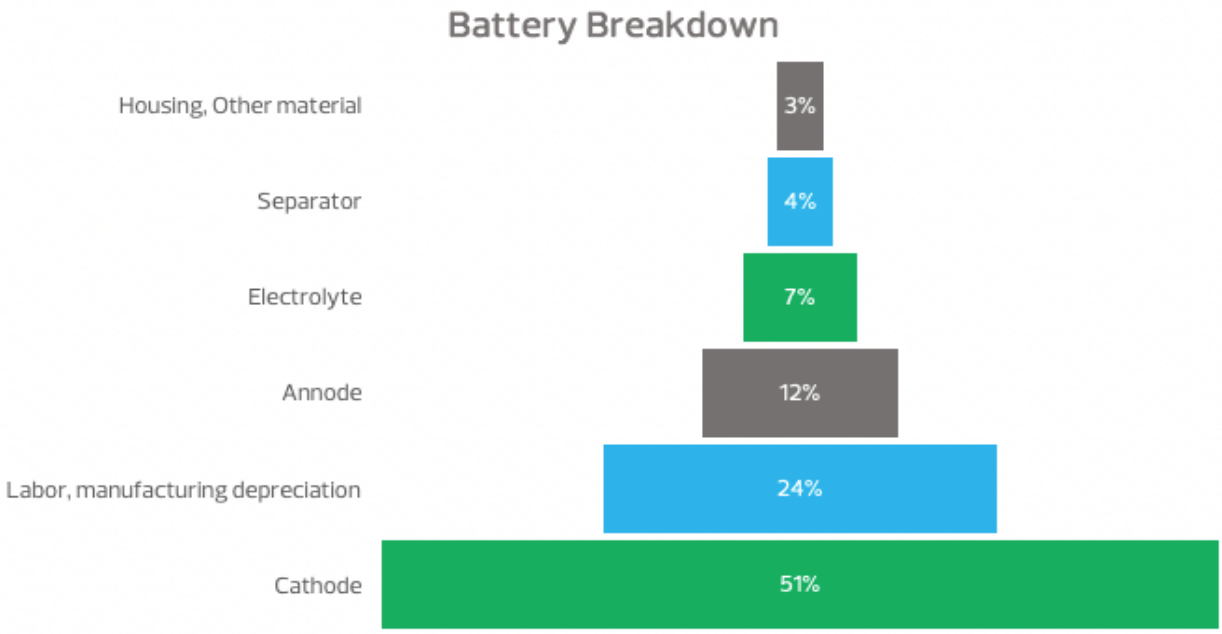
and sell them to consumers. While not part of the supply chain, charging solution providers are essential to the EV ecosystem as well.



Source: https://www.morningstar.co.uk/uk/news/216040/stocks-to-watch-in-the-electric-vehicle-supply-chain.aspx

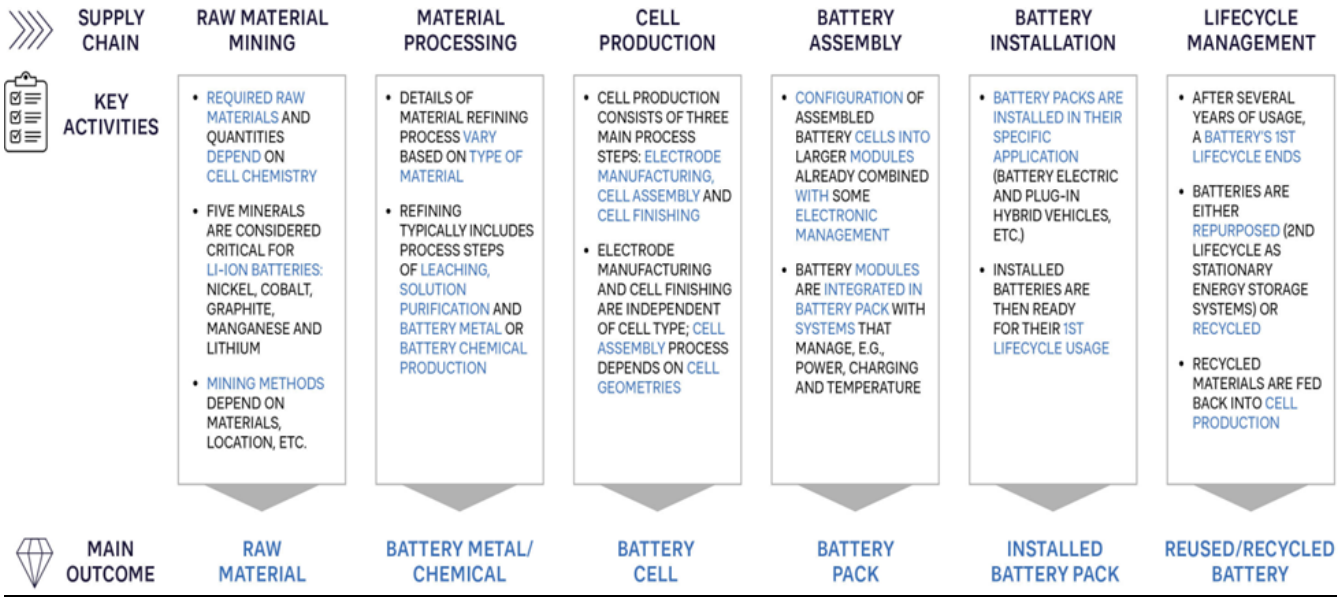
1.7.1 Batteries

Raw materials are a vital input for battery cell manufacturing. As per the S&P report referred above, more than two-thirds of the total cost per battery cell goes to raw materials. The cathode is the most expensive component, making up about 51% of total battery cell while the anode only accounts for one-fourth of the cathode's cost. The difference comes from metals used to produce cathode and anode—the lithium, nickel, cobalt and manganese to produce the cathode are more expensive than the graphite in the anode. Raw material supply is concentrated in mineral-rich regions such as Africa, South America and Australia.



Source: Bloomberg NEF

The raw material supply chains may change as battery technology improves and different and cheaper raw materials are needed to feed the new versions.



Source: https://www.adlittle.com/en/insights/prism/achieving-resilience-and-sustainability-ev-battery-supply-chain

1.7.2 Motors

EV automakers are either producing motors and controllers internally (e.g., Tesla and BYD) or sourcing them from third-party suppliers. Major motor suppliers include Siemens, Hitachi and Continental. The core technology in the controller is the Insulated Gate Bipolar Transistors (IGBT) inverter, which inverts direct current from the battery into alternating current for the motor. Its market share is highly concentrated among several top players such as Infineon, Mitsubishi and Fuji.

1.7.3 Non-Power Components

Other than the power system, EVs share similar components with traditional ICE vehicles. Non-technological components including the car body, interior, seats and wheels, and technological components such as Advanced Driving Assistance System (ADAS) and its sensors and automotive electronics are necessary for EVs to function.

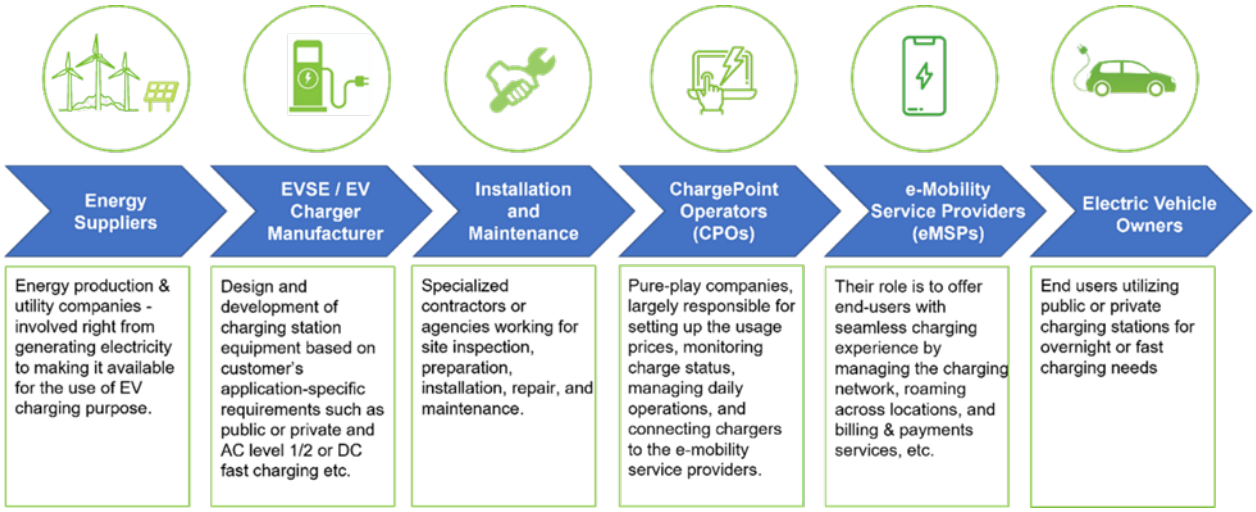
Meanwhile, demand for technological components with semiconductor chips is likely to increase. EVs are evolving to utilize electronic control units for almost every component, from powertrain to breaks and headlights. Over the next five years, ADAS and its sensors and automotive electronics are estimated to be the fastest-growing non-power segments, growing at a rate of 150% and 22%, respectively as per the S&P Report.

1.7.4 Charging

Looking ahead, energy efficiency, raw materials and environmental impact present three major challenges and opportunities for EVs. The industry is continuously exploring various new technologies for better battery efficiency and slower depreciation, such as solid-state batteries

and hydrogen fuel cells. To mitigate the risk of raw material shortage and to lower costs, many downstream automakers are seeking upstream integration by directly cooperating with or investing in battery cell producers. For example, Tesla built "Gigafactories" with Panasonic to produce its battery modules and packs in the U.S. and signed a supply contract with Piedmont trying to ensure lithium supply.

Finally, as demand for EVs grows, the use of lithium-ion batteries will likely surge. Reducing toxic materials such as cobalt in batteries and recycling batteries in a cost-effective way may help to alleviate the impact on the environment.



Source: https://www.einfochips.com/blog/digital-transformation-leading-the-way-for-ev-charging-value-chain/

1.8 The Green Aspect of EVs

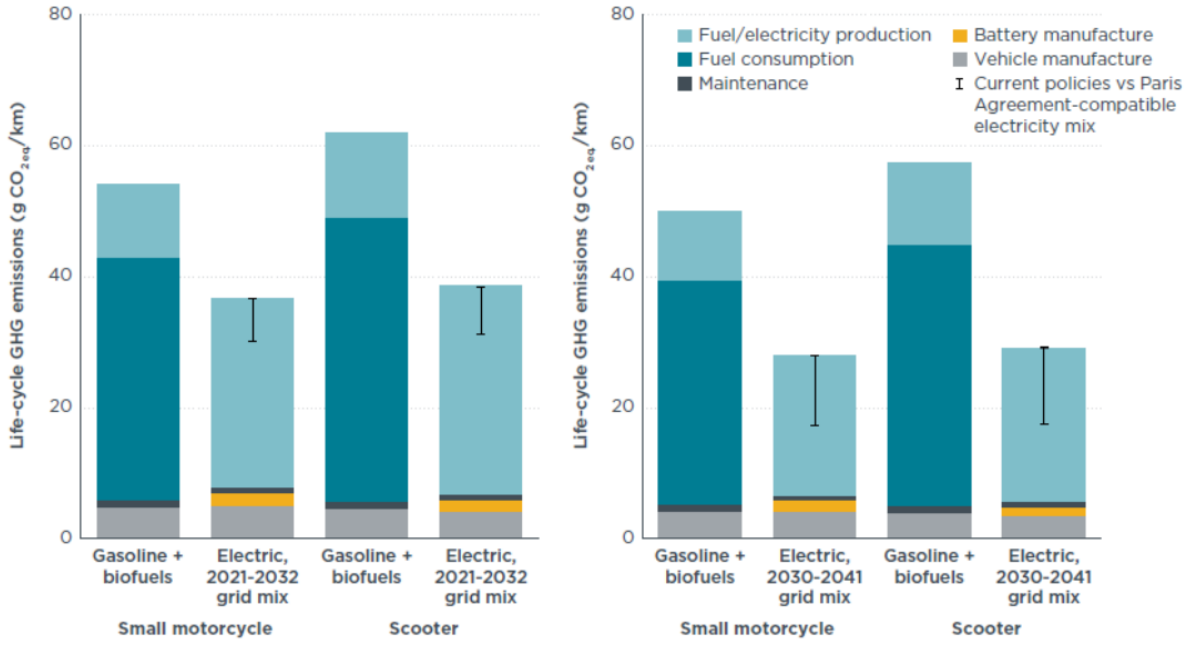
If the global transportation sector is to align with efforts supporting the Paris Agreement's goal of limiting global warming to below 2 °C pre-industrial levels, the greenhouse gas (GHG) emissions from road transport by 2050 need to be dramatically lower than today's levels, and all countries including Pakistan must put in their best effort to pull it through.

As per estimates based on our discussions with local EV operators and secondary sources, following are the CO2 savings that can be achieved through EV operations as compared to ICE vehicles:

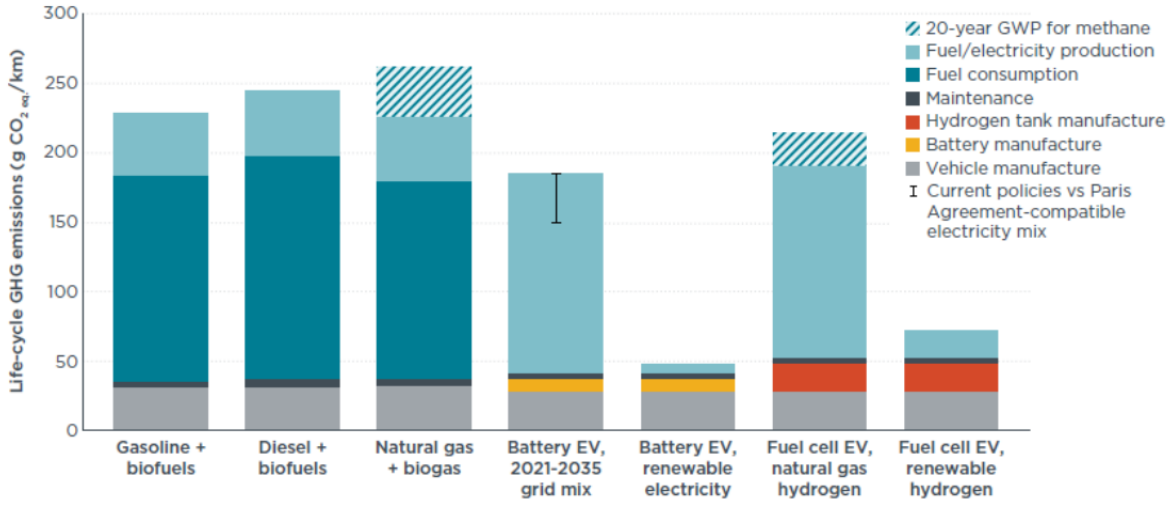
CO2 Emissions (g per Km)	2 Wheelers	3 Wheelers	4 Wheelers	Buses
ICE	103	130	300	1300
EV	22	33	92	670
GHG Reduction (g)	81	97	208	630
% Reduction	79%	75%	69%	48%

Source: Based on averages of values from various local & international sources (Numbers may vary depending on electricity sources)

A recent study of the Indian EV market by "The International Council on Clean Transportation (ICCT)' in 2021, carried out a Life-Cycle Assessment (LCA) of the GHG emissions of vehicles in India and came out with the following salient results. The results depict emissions linked with vehicle usage and do not cover the supply chain emissions, such as mining of minerals used for battery production etc.:



- Electric motorcycles and scooters have 33%–45% and 38%–50% lower life-cycle GHG emissions, respectively, than average new ICE models, depending on the development of the electricity mix. For motorcycles and scooters projected to be registered in 2030, the life-cycle GHG emissions benefit is at 45%–66% and 50%–70%



- BEVs (Battery Electric Vehicles) have the lowest life-cycle GHG emissions. Already for cars registered in India, they are 19%–34% lower than for average new ICE cars, depending on whether the electricity mix will develop according to current policies or what is required to meet the Paris Agreement. For BEVs projected to be registered in 2030, the life-cycle

GHG emissions benefit over gasoline cars increases to 30%–56%. When entirely powered by renewable energy, BEVs correspond to 80% lower lifecycle GHG emissions than gasoline cars, and this is including the emissions from the construction of additional renewable electricity installations.

- Life-cycle emissions of Fuel Cell Electric Vehicles (FCEVs) registered in 2021 are only about 16% less than for average new gasoline cars if they are powered by hydrogen produced through reforming methane from natural gas ("grey hydrogen"). Utilizing hydrogen produced from renewable electricity ("green hydrogen"), instead, would result in 68% lower life-cycle GHG emissions for FCEVs. Renewable energy powered FCEVs show slightly higher life-cycle emissions than BEVs powered by the same renewable electricity.; This is because the electricity-based FCEV pathway is approximately three times as energy intensive as the BEV pathway, and as such, emissions from the construction of additional renewable electricity installations were considered. Renewable energy emissions only account for electricity generation from these sources and do not cover their supply chain emissions such as associated with production of renewable energy equipment production etc.

1.9 Conclusion

In conclusion, this chapter provides a comprehensive overview of the EV technology landscape, covering key aspects of EV design, technology, battery types and chemistries, motor variants, battery management systems, motor controllers, telematics, supply chains, charging infrastructure, and charging port variants.

The chapter also highlights the importance of continued innovation and development in EV technology to meet future emissions targets and support the growth of the EV sector.

It also emphasizes the need for efficient and reliable supply chains, comprehensive and competitive EV charging infrastructure, and user-friendly interfaces for EV fleet charging management.

Overall, the chapter provides valuable insights into the current state and future direction of the EV industry, highlighting the critical role that EVs will play in achieving a low-carbon transportation sector, and sets the stage for the remaining report.

Section 02

GLOBAL EV LANDSCAPE

The global electric vehicle (EV) landscape has undergone a remarkable transformation in recent years, driven by advancements in technology, growing environmental awareness, and government initiatives aimed at reducing carbon emissions. Across the globe, nations are increasingly embracing electric vehicles as a crucial component of their transportation ecosystems, aiming to mitigate the impact of traditional combustion engines on both air quality and climate change.

One of the most significant trends shaping the global EV landscape is the rapid expansion of charging infrastructure. Governments, private companies, and energy providers are investing heavily in building charging stations to alleviate range anxiety and encourage EV adoption. This infrastructure development is essential for facilitating long-distance travel and enabling consumers to transition seamlessly to electric vehicles.

Moreover, the automotive industry is witnessing a surge in the production and adoption of electric vehicles, with major manufacturers committing to phasing out internal combustion engine (ICE) vehicles in favor of electric alternatives. This shift is not only reshaping the competitive dynamics within the industry but also driving innovation in battery technology, vehicle design, and sustainable manufacturing practices. As the global EV landscape continues to evolve, it presents both challenges and opportunities for stakeholders across the automotive value chain, from manufacturers and suppliers to policymakers and consumers.

2.1 Evolution of the Global EV landscape

The global electric vehicle (EV) market has seen remarkable growth and transformation over the past decade, with adoption rates and technological advancements accelerating significantly. The section below discusses the evolution of Hybrid and all Electric Vehicles:

2.1.1 Hybrid Electric Vehicles (HEVs) [4]

The history of hybrid cars stretches back over a century, bridging traditional internal combustion engine (ICE) and fully electric vehicles. A hybrid car is defined as any car that runs on two sources of power. The most common hybrid powertrain combines a gasoline engine with an electric motor. While it may seem that hybrids are a recent phenomenon, the technology has been around since the creation of the automobile.

a) The Beginning (1890- 1900s)

The first hybrid car was built in the year 1899 by engineer Ferdinand Porsche. Called the System Lohner-Porsche Mixte, it used a gasoline engine to supply power to an electric motor that drove the car's front wheels. The Mixte was well-received, and over 300 cars were produced. The demand for hybrids began to wane, however, when Henry Ford started the first automobile assembly line in 1904. Ford's ability to produce gasoline-powered cars and offer them at low prices dramatically shrunk the hybrid vehicle market. While hybrids were produced well into the 1910s using the Mixte's technology, most sold poorly because they had higher prices and less power than their gasoline-powered counterparts. Hybrids soon became a thing of the past, beginning a nearly 50-year period where they were merely an afterthought.

b) Renewed Interest (1960 – early 1990s)

In the 1960s, the United States Congress, in an attempt to reduce air pollution, introduced legislation that encouraged greater use of electric vehicles. While the government tried to garner support for hybrids, renewed public interest did not gain momentum until the Arab oil embargo of 1973. This oil crisis caused the price of gasoline to soar while supply fell dramatically. Over the next 25 years, auto manufacturers spent billions of dollars on the research and development of hybrid technologies. Despite this, very few vehicles were produced that could both reduce the world's dependence on oil and compete with gasoline vehicles on price and performance It wasn't until Toyota released the Prius in Japan in 1997 that a viable alternative to gas-powered vehicles was introduced.

c) The Revival (2000s)

In 1999, the Honda Insight became the first mass-production HEV released in the United States. The two-door, two-seat Insight may have been first, but it was the Toyota Prius sedan, released in the United States in 2000, that gave hybrid technology a strong foothold. In the years since its United States introduction, the Prius has become synonymous with the term "hybrid." It is the most popular HEV ever produced, and auto manufacturers around the world have used its technology as a basis for countless other vehicles. This was followed by Honda releasing its second-generation Insight, and Chevrolet introduced the Volt. As hybrid technology continues to improve, it will continue developing an even stronger foothold in the world's auto market.

[4] BBC TopGear https://www.topgearmag.in/news/industry/a-brief-history-and-evolution-of-hybrid-cars

d) The Future (2030s)

An increasing number of automakers now offer hybrid and plug-in hybrid versions of their vehicles. For example, the Toyota RAV4 Prime is a plug-in hybrid capable of 42 miles of driving on electric power, with a total combined range of 600 miles. It's even rated at 94 MPGe with over 300 horsepower and happens to be one of Toyota's fastest models. As per recent trends in the US, the hybrid demand has surged unexpectedly as compared to pure EVs mainly due to range anxiety and persisting technical Issues with EVs, however, as the commercial charging infrastructure grows and with ongoing R&D, consumers are expected to get more comfortable with EVs.

As always, the story of the automotive industry is tied to technology. Autonomous vehicles are increasingly showing up on the road in the form of autonomous buses, robo-taxis, and delivery robots or drones. The conversation around the next generation of power is also beginning to take shape, with discussions around renewable diesel, hydrogen fuel cells, and liquified natural gas (LNG) as a fuel. There is also the development of 5G vehicle-to-vehicle (V2V) communication, which would allow cars to communicate with each other and interface with the road for a more data-driven experience. Even the logistics industry is exploring concepts for the electrification of shipping and drone-based last-mile solutions for the delivery of goods.

2.1.2 Electric Vehicles (EVs)

a) The Beginning (1800 – 1900s)

The invention of the electric motor is often credited to Hungarian engineer Anyos Jedlik, while Scottish chemist and engineer Robert Davidson is credited with creating the world's first electric vehicle, first shown to the public in an exhibition in Aberdeen in 18395. The vehicle used a simple electric motor and battery – essentially a wooden box with liquid-acid electrolyte and zinc plates – but proved that electricity could move people in vehicles.

The battery took some time to catch up to Davidon's aspirations. French physicist Gaston Plane invented commercial rechargeable lead-acid batteries in 1859, but it was English firm Elwell and Parker who created the first useable electric cars. Other British firms got in early, including Edinburgh-based Maldevic with its four-wheeled carriages driven by a fifth central wheel underneath.

The years around the turn of the 20th century are often described as a golden age of electric motoring, due to a strong EV presence on the streets of US cities.

In 1897, the first commercial users of electric carriages were New York City taxi drivers; the city's fleet eventually grew to over 60 electric cabs. Some historians estimate that around a third of cars on American streets in 1900 were electric, while some sources claim EVs outsold combustion cars in 1899 and 1900.

b) The Internal Combustion Revolution (early 1900s)

Mass production techniques pioneered by Ford with the Model T in 1908 made combustion-engine cars cheaper, plus easier to use owing to advances such as electric starter motors. Growing road networks also meant growing demand for faster cars with longer ranges and quicker fill-up

[5] https://www.autoexpress.co.uk/car-news/electric-cars/101002/history-of-the-ev-from-the-first-electric-car-to-the-present-day

times. These developments led to a dark age for electric cars which lasted for much of the 20th century, as affordable petrol vehicles revolutionized the industry.

c) Revival of Electric Cars (1960 – 1990s)

A mild revival was sparked during the oil crises of the seventies, and the electric car made a cameo in 1971; the electric Lunar Roving Vehicle was the first car driven on the moon. Electrified versions of the BMW 1600, boasting 43bhp Bosch motors and regenerative braking, starred at the 1972 Munich Olympics as marathon support vehicles.

The car manufacturers began to return to EVs in the nineties in response to tightening environmental laws, their offerings however were produced in small numbers and most were crude conversions of conventional models.

In 1996, General Motors (GM) released the EV1 – the first mass-produced, purpose-built modern electric car from one of the industry's key players. It was released under a leasing program, and just over 1,000 were produced. However, GM axed the EV1 program in 2003 as it reportedly believed that electric cars occupied an unprofitable niche of the automobile market.

In 1991, Sony became the first company to industrialize the production of lithium-ion batteries for its portable electronic devices, a move that would go on to become instrumental in the viability of electric cars in the modern age.

d) The Modern Electric Car (2000s)

The advancements in technology, government subsidies, new regulations, increasing environmental concerns and, importantly, large technological advances – especially in the battery arena sparked the rebirth of the electric cars.

By 2013, the reduction in the price of lithium-ion batteries drove further global development, while Estonia[6] (widely recognized as a hub for digital innovation in multiple domains), became the first country to lay down a public nationwide EV fast charging network.

During 2013 in Estonia, charging points were distributed on all major roads, in towns, next to petrol stations, cafes, shops, banks and ports. The charging network was state-owned until 2018, when it was sold to the only qualified bidder, Estonia's largest distribution grid operator, Elektrilevi. Today there are over ten companies operating EV charging networks in Estonia with the total charging points increasing to thousands.[7]

In addition to the nationwide grid of quick chargers, Estonia offered subsides for the acquisition of EVs; up to €18,0001 (ca. $25,000) or 50% of the EV's listed price was reimbursed[8]. An EV rental program was also run by the government to familiarize Estonian drivers with electric mobility. Despite these efforts, this early adoption did not create a vibrant market in Estonia for EVs. This is mainly because Estonia based its EV program on several assumptions that failed to materialize. It was expected that EV prices would drop much faster and that subsidies would not be necessary

[6] https://estonianworld.com/technology/estonia-becomes-the-first-in-the-world-to-open-a-nationwide-electric-vehicle-fast-charging-network/

[7] https://investinestonia.com/in-estonia-theres-always-a-charger-nearby/

[8] https://www.researchgate.net/publication/348186972_Estonian_Experience_with_Electric_Mobility_Is_There_a_First-Mover_Advantage_with_EVs

after a few initial years. In reality, the car sales prices remained comparatively high in 2014, when the program ended. Estonia could not keep up with the public investment needed for this effort.

A survey conducted in 2019 revealed that most Estonians still saw the higher acquisition cost of EVs as the biggest barrier to electric mobility. In addition, Secondly, the EV program incorrectly interpreted core consumer preferences with respect to range anxiety and the convenience of charging. Despite relatively high gasoline and diesel prices in Estonia, car owners were not ready to accept relatively short EV driving ranges and frequent charging, which lasted several times longer compared to visiting a conventional gas station. EVs were mostly purchased by those who had the opportunity to charge at home, while the residents of apartment buildings, which are numerous in Estonia's largest cities, did not purchase EVs regardless of the availability of the public charging infrastructure. Currently, Estonia's EV penetration is comparable to its Baltic neighbors, which didn't develop public charging infrastructure this aggressively. In hindsight, EV adoption in Estonia has been slowed by a number of challenges, ranging from technological (short driving range), to economic (high upfront cost), to consumer preferences (long charging times, limited model selection). Being the first mover has not created a vibrant EV market in Estonia, but it has likely resulted in positive knowledge spillovers about electric mobility (learning by doing) and non-market benefits (reduced air pollution, carbon savings). However, nearly a decade later, the importance of these past barriers has decreased significantly.

In this five-year period between 2015-2019, global Initiatives were accelerated by the signing of the Paris Agreement and the formation of the Zero Emissions Vehicle (ZEV) alliance. The European Battery Alliance, launched by the European Commission and China's battery guidelines promoted the development of competitive battery manufacturing across the globe. By 2018, many different and improved models had entered the market and EV adoption in China, US and Europe had increased significantly.

Successful early pioneers included the Nissan Leaf in 2010 and the Renault Zoe in 2013, with the former still competitive today. Cars like these have helped the EV to drop its sideshow reputation in recent years.

The shift in public perception can also be attributed to Tesla, which thoroughly disrupted the market with its high-tech, long-range, fast-charging Model S in 2012 – long before most established manufacturers had realized the potential of EVs, which at that stage remained a niche choice. The American brand was also an early proponent of increased autonomy and remains at the forefront with its AI-run driver assistance systems today.

Early responses to Tesla's growing popularity included purpose-built EVs from big names such as Jaguar with the I-Pace in 2018 and Audi with the e-tron SUV in 2019. Many makers revealed big plans for extensive all-electric ranges, including Mercedes with its EQ models and the Volkswagen ID lineup.

Today, many manufacturers are already rearranging their ranges and stripping away electric-only sub-brands hastily created just a few years ago. The EV has finally gone mainstream.

Last few years have seen governments, and corporations around the world make ambitious commitments to electrifying vehicle fleets. Policies and Regulations like the US inflation Reduction Act (IRA) and the EU's fit for 55 package set aggressive targets for EV adoption[9]. By 2023, global EV sales have reached almost 40 million (18% of all new car sales). China was at the top with 60% of the global sales share, followed by Europe at 25% and the US at 10%. By 2030, EVs are expected to make 35% of all global car sales.

2.1.3 EV Infrastructure and Supply Chain

With the growth in EV industry, the investment in battery manufacturing has also surged with around $500 billion announced for EV supply chains between 2022-2023. The development of an extensive public charging network is also crucial to support mass adoption. Recently many countries have removed subsidies available to the EV market and increased support for supply chain equipment.

2.2 EV Global Market Segments

The global market for EVs is undergoing a significant segmentation process, driven by diverse consumer preferences, technological advancements, and governmental policies. At its core, this segmentation revolves around several key factors, including vehicle type, battery technology, range, and price point. Electric cars, hybrid vehicles, and electric two-wheelers represent distinct segments catering to varied consumer needs and usage patterns. Additionally, the market is stratified based on battery types, ranging from traditional lithium-ion to emerging solid-state and graphene-based technologies, each offering unique advantages in terms of performance, charging speed, and longevity. Furthermore, EVs are segmented by range capabilities, from short-range city commuters to long-range electric SUVs suited for intercity travel. Lastly, pricing remains a crucial factor, with luxury EVs targeting affluent consumers and affordable options aimed at mass adoption. As the EV market continues to evolve, this segmentation will likely become even more refined, reflecting the diverse demands of global consumers and the ongoing innovations within the industry.

The key global market segments for electric vehicles (EVs) typically include:

- **Passenger Cars**: This segment comprises electric cars designed for personal use. It's the most prominent segment in the EV market and includes various types of vehicles, such as sedans, hatchbacks, SUVs, and sports cars. The number of available electric car models nears 600, two-thirds of which are large vehicles and SUVs due to higher end-user demand. Additionally, from the car manufacturer's perspective, the platform containing the battery has a certain thickness, which inherently adds to the height compared to a similar ICE car, thus making an electric SUV or crossover more practical and cost-efficient than an electric sedan or hatchback. Major carmakers have announced launches of smaller and more affordable electric car models over the past few years. However, when all launch announcements are considered, far fewer smaller models are expected than SUVs, large models, and pick-up trucks.

[9] https://kpmg.com/xx/en/home/insights/2021/11/the-european-green-deal-and-fit-for-55.html#:~:text=On%2014%20July%202021%2C%20the,least%2055%20percent%20by%202030.

- **Commercial Vehicles/ Light Commercial Vehicles (LCVs)**: This segment includes electric vehicles designed for commercial purposes, such as delivery vans, trucks, buses, and even electric taxis. Fleet operators and logistics companies are increasingly adopting electric commercial vehicles to reduce emissions and operating costs. One in twenty-five LCVs sold in 2023 were electric, following the path set by passenger cars. Sales of electric trucks increased 35% in 2023 compared to 2022 and surpassed the sale of electric buses for the first time.

- **Two-Wheelers (2Ws)**: The 2Ws EV market consists of electric vehicles that have two wheels, such as electric motorcycles and electric scooters. These vehicles are popular in densely populated urban areas where they offer a convenient and eco-friendly mode of transportation.

- **Three-Wheelers (3Ws)**: The 3Ws EV market includes electric vehicles that have three wheels, like electric auto-rickshaws and three-wheeled motorcycles. These vehicles are widely used as taxis or for cargo transportation in many developing countries due to their lower costs compared to traditional four-wheeled vehicles and their ability to navigate through congested traffic. Electric three-wheelers are popular in markets like India, China, Southeast Asia, parts of Latin America and Africa. China, India, and all ASEAN countries remain far ahead of all other regions in terms of electric 2/3W sales, where other regions combined account for less than 5% of global sales. Türkiye ranks as the top market outside of Asia, followed by France, the Netherlands, Italy, and Spain[10].

Another variant of EVs but based on its battery differentiation is the Fuel Cell **Electric Vehicles (FCEV)** which has been launched in passenger cars as well as heavier EV variants. The FCEV segment (EVs powered by Hydrogen), although much smaller than the EV segment, is also on the growth trajectory. In 2023, the global stock of fuel cell electric vehicles (FCEVs) increased by around 20% compared to 2022, reaching 87,600 by the end of the year. Of the 15,400 new FCEVs hitting the roads in 2023, about half were cars, around one-quarter were medium- and heavy-duty trucks, and almost 10% were buses. The fastest-growing segment was LCVs, for which the stock approximately tripled in 2023, mainly due to sales in China. The stock of heavy-duty fuel cell trucks doubled. At the end of 2023, Asia accounted for over 70% of FCEVs worldwide, followed by North America with 20% and Europe with less than 10%. Korea is the leading country in terms of FCEV stock, accounting for almost 40% of all FCEVs, mainly due to its large passenger car fleet (exceeding 33,000). The U.S. is home to 18,200 FCEVs, almost all of which are fuel cell cars. The United States has the second-largest fuel cell car stock worldwide, with around 30% of the global stock[11].

2.3 Charging Infrastructure

Home charging is currently the most common means of charging electric cars. This is a convenient and relatively cheaper means of charging for EV owners with parking space that is equipped with

10 Global EV Outlook 2024, IEA
11 Global EV Outlook 2024, IEA

a charging station. The availability of home charging varies substantially between regions and is linked to differences in urban, suburban, and rural populations as well as income brackets.

In regions where the voltage of the power grid is 220V or above, EV owners can charge their vehicle from a regular domestic socket overnight. This holds true in Europe, Australia, large parts of Latin America, and most of Asia. In regions where the voltage is lower, typically 100–120V, recharging speeds from regular domestic sockets are much slower and can present a safety hazard.

In dense cities, where most people live in multi-unit dwellings, access to home charging is more limited and EV owners rely more heavily on public charging. This is most apparent in Korea, which is one of the world's most densely populated countries and has the highest ratio of public charging capacity to EVs. The United Kingdom has one of the highest reported accesses to home charging, due to United Kingdom's smart charge point regulations and to the high share of EV owners that own a home in which a charger can be installed.

The development of public charging infrastructure is key to enabling more widespread adoption of EVs. The global number of installed public charging points was up 40% in 2023 relative to 2022, and growth for fast chargers outpaced that of slower ones. It is important to ensure that transmission and distribution grids are appropriately sized and equipped. Overall, China leads electric vehicle supply equipment (EVSE) deployment, with targets to fully cover cities around highways by 2030, as well as expanded rural coverage. There's a trend in other developed markets to expand support for EVSE while reducing funding for vehicle incentives.

Charging for electric heavy-duty vehicles (HDVs) creates a need for dedicated charging equipment to cater to the longer charging times required as charging HDVs on regular charging facilities could put pressure on the system. In 2023, electric buses accounted for 3% of total global bus sales. Electric truck sales jumped 35% compared with 2022. For mass market adoption, especially in case of HDVs, affordable access to public charging infrastructure through policy support, careful planning and coordination will be needed. The HDV charging infrastructure is currently in the early stages of development and deployment.

Battery swapping technologies are also on the rise especially in countries like India and the ASEAN countries where there's a huge market for 2/3 Wheelers. Battery swapping[12] is currently most developed in China. Battery swapping can be completed in as little as five minutes, can help to extend battery life through more controlled charging, and can spread power demand over a longer period, thus reducing pressure on the electricity grid.

2.4 Latest Global Sales Trends

Global EV sales are on the rise globally. In the first quarter of 2024, sales grew by around 25% compared with the first quarter of 2023. Electric car sales in 2023 were 3.5 million higher than in 2022, a 35% year-on-year increase. This is more than six times higher than in 2018.[13] By the end

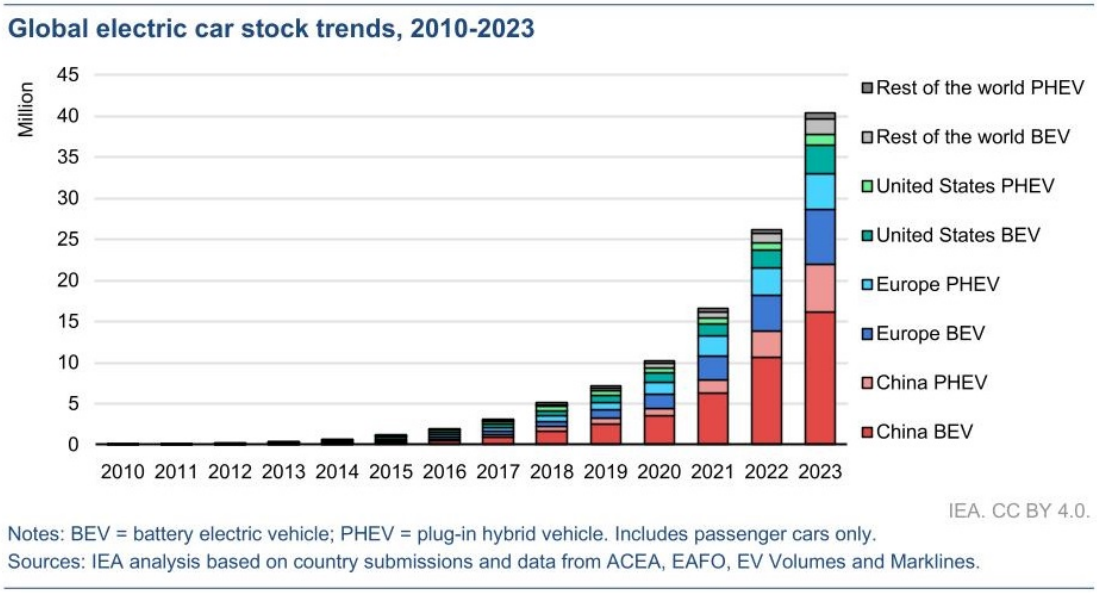
[12] Global EV Outlook 2024, IEA
[13] Global EV Outlook 2024, IEA

of 2024, electric car sales could reach around 17 million units, which accounts for more than one in five cars sold worldwide[14].

Almost 14 million new electric cars were registered globally in 2023, 60% of which were in China, 25% in Europe, and 10% in the United States, bringing their total number on the roads to 40 million. This accounts for 18% of all cars sold[15].

Electric car sales in emerging markets and developing economies also picked up in 2023 in countries such as Vietnam (around 15% of all cars sold) and Thailand (10%). In emerging economies with large car markets, shares are still relatively low, but are expected to increase owing to the purchase subsidies and incentives for EV and battery manufacturing.

In India, electric car registrations were up 70% on a year-on-year basis to 80,000 units. In Latin America, electric car sales reached almost 90,000 in 2023, with markets in Brazil, Colombia, Costa Rica, and Mexico leading the region. In the Middle East, Jordan boasts the highest electric car sales share, at more than 45%, supported by much lower import duties relative to ICE cars, followed by the United Arab Emirates, with 13%.



The absence of small and cheaper electric car models is a significant hindrance to wider market uptake in most developing economies. Many of the available car models are SUVs or large models, targeting consumers of high-end goods, and far too expensive for mass-market consumers, who often do not own a personal car in the first place.

In India, while Tata's small Tiago/ Tigor models, which are priced between USD 10,000 and USD 15,000, accounted for about 20% of total electric car sales in 2023[16], the average best-selling small ICE car is priced around USD 7,000.

[14] https://www.globalfleet.com/
[15] https://reglobal.org
[16] Global EV Outlook 2024, IEA

The sales share of electric 2/3Ws was just 13% globally in 2023, while in terms of stock shares, 2/3Ws represent the most electrified road transport segment, with about 8% of 2/3Ws being electric. China sold the most electric 2/3Ws in 2023, with over 30% of the 2/3W sales being electric (decreasing from about 50% in 2022), followed by India (8%) and ASEAN countries (3%).

Although the global market for electric two-wheelers (2Ws) shrank 18% in 2023, continuing the downward trend of 2022, it was almost entirely due to supply chain challenges stemming from China's pandemic-related restrictions. The decline at the global level was largely driven by a 25% drop in China (which still commanded 78% of global sales), which continues to command the vast majority of global electric 2W sales.

In India – the second-largest electric 2W market globally – 2023 sales grew by 40% compared to 2022. The Indian electric 2W market is dominated by the five largest domestic manufacturers (Ola Electric, TVS Motor, Ather, Bajaj and Ampere), which accounted for more than 75% of sales. The rapid growth seen in India is the result of strong policy support for EV deployment, such as the FAME II measure, which was first introduced in 2019 as a three-year purchase incentive policy.

Globally, the three-wheeler (3W) market grew 13% in 2023, to reach 4.5 million sales, 21% of which were electric, compared to 18% in 2022. Almost 1 million electric 3Ws were sold in 2023, reflecting 30% growth compared to 2022. The market is highly concentrated, with China and India together accounting for more than 95% of all electric and 80% of conventional 3W sales. India overtook China in 2023 to become the biggest market for electric 3Ws, with over 580,000 sales.

India saw its sales increase by 65% with respect to 2022, thanks to government financial incentives and resulting reductions in the cost of ownership of electric 3Ws. Sales in China declined 8% in 2023, to 320 000, making the country the second-largest electric 3W market[17].

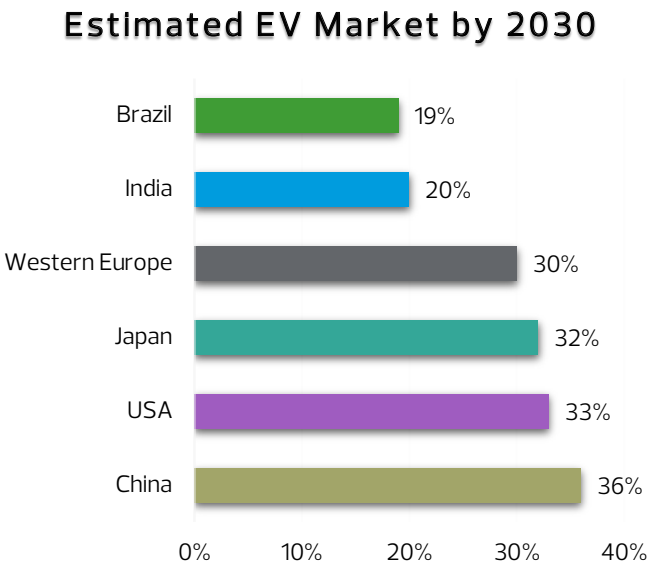
2.5 Future EV Sales Outlook

Global Electric Vehicle market size is expected to surpass US $700 Billion By 2030. Around 30% of global vehicles are likely to be electric by 2030; this translates to almost one in three cars on the roads in China and almost one in five in both the United States and European Union[18].

Recent policy developments in developed countries like Canada, the European Union and the United States around emissions targets continue to reinforce expectations for swift electrification. The strong growth expectations are driving investment in the EV supply chain also. Recent reports show that from 2022 to 2023, investment announcements in EV and battery manufacturing totaled almost USD 500 billion, of which around 40% has been committed. Taking the targets of the largest automakers together, more than 40 million electric cars could be sold in 2030[19].

[17] Global EV Outlook 2024, IEA
[18] https://www.morningstar.com
[19] Global EV Outlook 2024, IEA

Speaking of geographical trends in expected sales, while sales of electric cars are increasing globally, they remain significantly concentrated in a few major markets. In 2023, around 60% (8.1 million unit) of new electric car registrations were in China, 25% (3.2 million units) in Europe, and 10% (1.4 million new EV registrations) in the United States – corresponding to nearly 95% of global electric car sales combined. These countries also represent around two-thirds of total car sales and car stock, meaning that the EV transition in these markets has major repercussions in terms of global trends. Elsewhere globally, the EV sales remain limited, even in countries with developed car markets such as Japan and India.[20]



Source: IEA Global EV Outlook 2024

In 2024, the market share of electric cars could reach up to 45% in China, 25% in Europe and over 11% in the United States, underpinned by competition among manufacturers, falling battery and car prices, and ongoing policy support. The growth in EV sales is also attributed to various factors, including increased consumer interest, more available models from different manufacturers, and supportive policies for EV adoption. As the market matures, the industry is entering a phase marked by increased price competition and consolidation.

Owing to the high levels of investment in the past 5 years, global EV battery manufacturing capacity far exceeded demand in 2023, at around 2.2 terawatt-hours and 750 gigawatt-hours, respectively. Manufacturing capacity appears capable of keeping pace with demand: committed and existing battery manufacturing capacity alone are practically aligned to achieve net zero emissions by 2030. Such prospects are opening significant opportunities across the supply chain for battery and mining companies, including in emerging markets outside China, although surplus capacity has been hurting margins and may lead to further market consolidation[21].

2.6 Key Global Players & Competition:

The global electric vehicle (EV) market is witnessing fierce competition among key players driving innovation and market penetration. The market is highly competitive with several players dominating different market regions and segments. A list of major global 4W EV brands are mentioned below and similar lists for 2W and 3W are given in Annexure 3.

[20] Global EV Outlook 2024, IEA
[21] Global EV Outlook 2024, IEA

Tesla, Inc.: Founded by Elon Musk, Tesla is one of the most prominent names in the EV market holding over 50% of the US market share in 2023. They produce electric cars, battery energy storage from home to grid-scale, solar panels, and solar roof tiles. Tesla's Model S, Model 3, Model X, and Model Y have gained popularity worldwide. Tesla holds around 20% of the global market share.

Chinese company BYD is one of the largest EV manufacturers worldwide. In 2023 it boasted nearly 17% of the global EV market share. BYD's growth trajectory indicates its potential to surpass Tesla soon. In the fourth quarter of 2023, BYD outsold Tesla, reinforcing its position as a major player in the EV industry

Europe remains Volkswagen's strongest market. VW has made significant investments in electric vehicles under its "Electrify America" campaign. They are producing electric cars under various brands, including Volkswagen, Audi, Porsche, and others. In 2023, Volkswagen Group's share of the global market was 4.6%

GAC Aion New Energy Automobile Co., Ltd. is a Chinese vehicle manufacturer and the third largest in terms of unit sales in China as of 2023. It commands a 5.2% global EV market share,

Together Hyundai-Kia have a global market share of around 4.9%. They have continued to show good sales performance especially with models like Hyundai IONIQ 5, IONIQ 6, and the Kia EV

This Chinese joint venture between SAIC Motor, General Motors China, and Guangxi Auto (previously Wuling Group) owns 4.9% of the global market share. It is known for producing affordable electric mini cars.

[22] https:// www.visualcapitalist.com
[23] https://www.nbcnews.com
[24] www.volkswagen-group.com/en
[25] https://www.trendforce.com

Global Battery Electric Vehicle Market Share 2023

TESLA 19.9%

BYD 17.1%

2.9%

4.6%

AION 5.2%

2 %

3.6 %

2.6 %

4.9%

2.3%

Source: Trend Force. 2024

The Global EV market share[26] of these companies and for some other noteworthy players are depicted above.

Currently, the top 10 Battery Electric Vehicle (BEV) manufacturers collectively control 65% of the overall market. This significant share underscores the consolidation within the EV industry and the dominance of key players.

In a notable development, BYD outpaced Tesla in the fourth quarter of 2023, recording sales of 526,000 units compared to Tesla's 485,000. With this momentum, industry analysts anticipate BYD overtaking Elon Musk's automaker by the year's end.

As of the latest data, Tesla commands a formidable 19.9% share of the market, closely trailed by BYD at 17.1%. This tight competition reflects the shifting dynamics in the global EV landscape.

In 2022, BYD surpassed Tesla as the top producer of Electric Vehicles (EVs), encompassing both BEVs and non-BEVs, with 1.8 million vehicles produced compared to Tesla's 1.3 million. This milestone underscores BYD's robust domestic sales performance and signals its ambitions for global expansion.

Expanding beyond its stronghold in China, BYD has strategically entered the European market, initiating sales just over a year ago. Furthermore, plans to establish manufacturing facilities within European borders aim to mitigate EU tariffs on Chinese car imports, enhancing BYD's competitive positioning.

GAC Aion, another Chinese automaker, secured the third position on the list, displacing SAIC-GM-Wuling and Volkswagen to fourth and fifth places, respectively. This underscores the growing influence of Chinese manufacturers in the global EV arena.

Meanwhile, luxury brands BMW and Mercedes-Benz have accelerated their electrification efforts, ranking sixth and eighth, respectively. Hyundai Group's Hyundai and KIA maintain their positions compared to the previous year, signaling continuity amidst industry shifts.

2.7 Financial and Affordability Aspects

Electric cars are getting cheaper as competition intensifies, but the upfront cost remains more expensive than ICE vehicles. In China, it is estimated that more than 60% of electric cars sold in 2023 were already cheaper than their average combustion engine equivalent. Electric cars remain 10% to 50% more expensive than ICE equivalents in Europe and the United States, depending on the country and car segment.

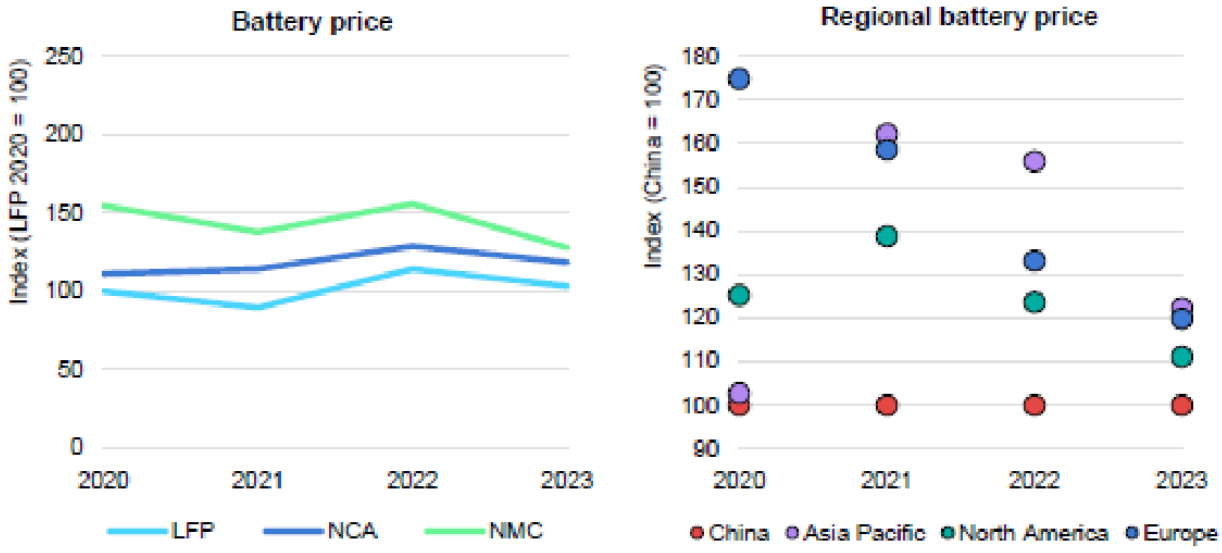
In 2023, two-thirds of available electric models globally were large cars, pick-up trucks or sports utility vehicles (SUVs), pushing up average prices. Current trends suggest that price parity could be reached by 2030 in major EV markets outside China for most models.

[26] Visualizing Global Electric Vehicle Sales in 2023, by Market Share, Marcus Lu (www.visualcapitalist.com)

The pricing strategies of car manufacturers will be crucial for improving affordability, as will the pace of EV battery price decline. China supplies the cheapest batteries, but prices across regions are converging as batteries become a globalized commodity. Lithium-iron-phosphate batteries – which are significantly cheaper than those based on lithium, nickel, manganese, and cobalt oxide – accounted for over 40% of global EV sales by capacity in 2023, more than double their share in 2020[27].

The price of all key battery metals dropped during 2023, with cobalt, graphite and manganese prices falling to lower than their 2015–2020 average by the end of 2023. This led to an almost 14% fall in battery pack price between 2023 and 2022, despite lithium carbonate prices at the end of 2023 still being about 50% higher than their 2015–2020 average.

Average battery price index by selected battery chemistry and region, 2020-2023



Notes: LFP = lithium iron phosphate; NMC = lithium nickel manganese cobalt oxide; NCA = lithium nickel cobalt aluminium oxide. Asia Pacific excludes China. Each year is indexed with respect to China price (100). Battery prices refer to the average battery price in a given region, including locally produced batteries and imports.

Source (Global EV Outlook 2024, IEA)

Going forward, technological innovation will remain important for scaling up new designs and chemistries such as sodium-ion batteries, which could cost significantly less than lithium-based batteries without requiring any lithium.[28]

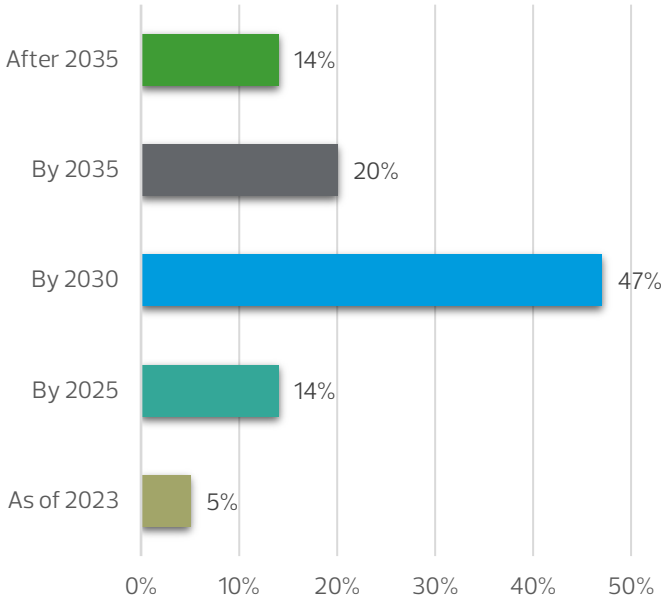
[27] Global EV Outlook 2024, IEA

[28] www.pv-magazine.com

In developing economies outside China, more affordable electric car models are arriving, and the future of electric two- and three-wheelers already looks bright.

In 2023, the majority of the electric car sales across major emerging and developing economies were large models that are unaffordable for the average consumer. However, smaller and much more affordable models launched in 2022 and 2023 have quickly become bestsellers, especially those by Chinese carmakers expanding overseas. Affordable electric two- and three-wheelers are also already available. Around 1.3 million electric two-wheelers were sold in India and Southeast Asia in 2023, accounting for 5% and 3% of total sales, respectively.

Expectations for EV and ICE cost parity



Source: Global EV Outlook 2024, IEA

As EV markets mature, second-hand electric cars will become more widely available. The prices of used electric cars are falling quickly and becoming competitive with ICE equivalents.

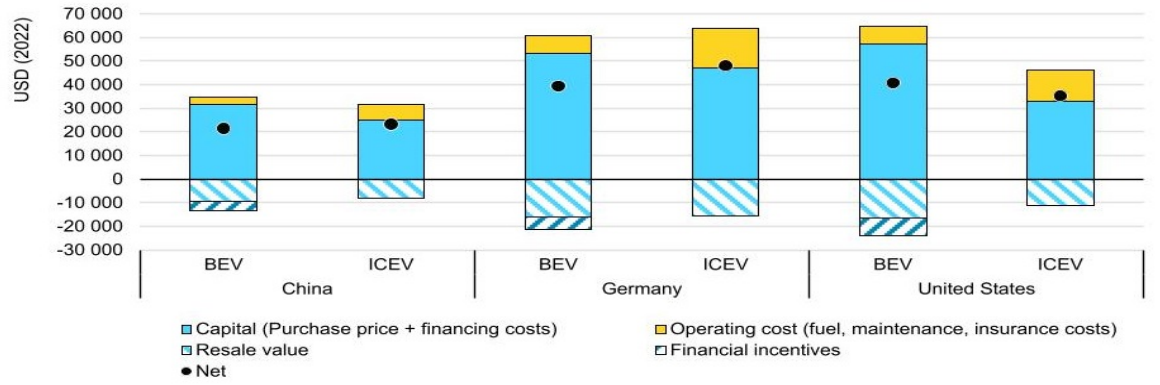
2.7.1 Total Cost of Ownership

Car purchase decisions typically involve consideration of retail price and available subsidies as well as lifetime operating costs, such as fuel costs, insurance, maintenance and depreciation, which together make up the total cost of ownership (TCO). Reaching TCO parity between electric and ICE cars creates important financial incentives to make the switch. In 2023, upfront retail prices for electric cars were generally higher than for their ICE equivalents, which increased their TCO in relative terms. On the upside, higher fuel efficiency and lower maintenance costs enable fuel cost savings for electric cars, lowering their TCO. This is especially true in periods when fuel prices are high, in places where electricity prices are not too closely correlated to fossil fuel prices. Depreciation is also a major factor in determining TCO: As a car ages, it loses value, and depreciation for electric cars tends to be faster than for ICE equivalents, further increasing their TCO. Accelerated depreciation could, however, prove beneficial for the development of second-hand markets.

TCO's would differ for various geographies based on comparative upfront costs of ICE and EV vehicles, correlation of fuel and electricity costs, average travel distances, subsidies, quality/ durability of components etc. As per the IEAs' Global EV Outlook 2024 report, in Germany, it is estimated that the sales-weighted average price of a medium-sized battery electric car in 2022 was 10-20% more expensive than its ICE equivalent, but 10-20% cheaper in cumulative costs of ownership after 5 years, thanks to fuel and maintenance costs savings. In the case of an electric SUV, It Is estimated that the average annual operating cost savings would amount to USD 1,800 when compared to the equivalent conventional SUV over a period of 10 years.

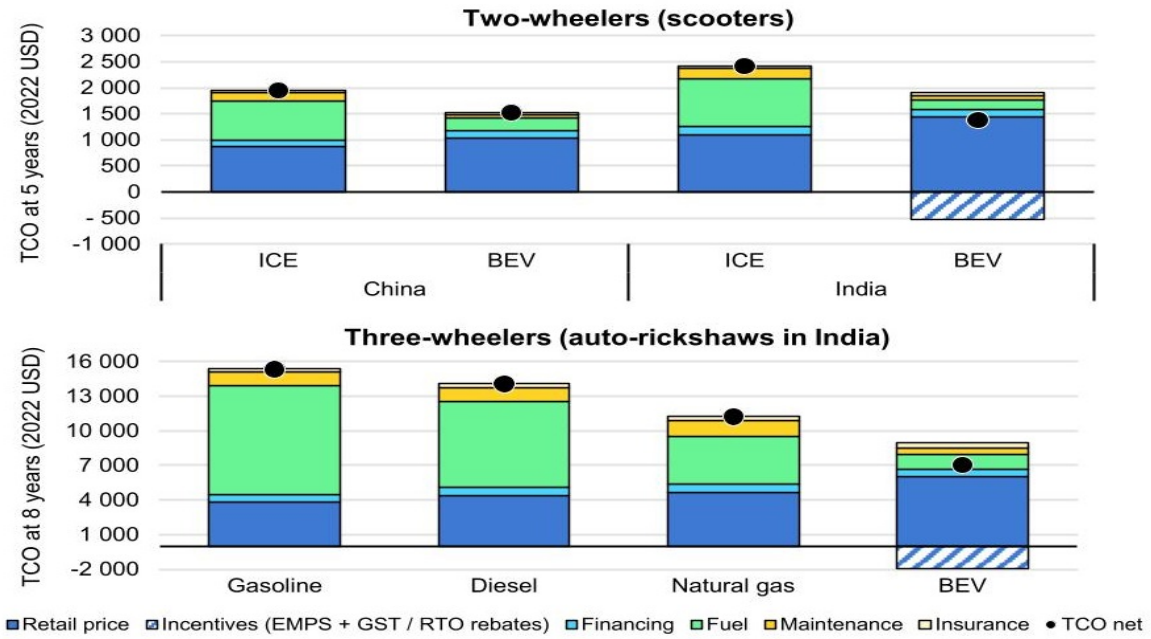
In the United States, despite lower fuel prices with respect to electricity, the higher average annual mileage results in savings that are close to Germany at USD 1,600 per year. In China, lower annual distance driven reduces fuel cost savings potential, but the very low price of electricity enables savings of about USD 1,000 per year. These figures provide an indication of how long it would take to recoup the initial purchase price gap between a BEV and its equivalent ICEV through operating cost savings. In developing economies, some electric cars can also be cheaper than ICE equivalents over their lifetime.

Breakdown of the cost of ownership for a sales-weighted average medium-sized battery electric and conventional car purchased in 2022, 5 years after purchase, by country



For 2W EVs, the TCO is even better – An electric 2W purchased in 2024 (assuming sales-weighted average prices from 2023) in India for example after 5 years of ownership would be more than 40% cheaper than its ICE equivalent over the same period. For 3W EVs in the Indian market, even when considering the most cost-effective ICE 3W running on natural gas, the electric model achieves TCO parity as soon as 2 years after purchase and works out about 40% cheaper over an 8-year lifetime.

Breakdown of total cost of ownership of two- and three-wheelers in China and India, 2023



2.8 Conclusion

The global EV landscape has undergone significant transformations in recent years, with exponential growth projected for the next decade. The market is diversifying, with a growing variety of models available across different price segments.

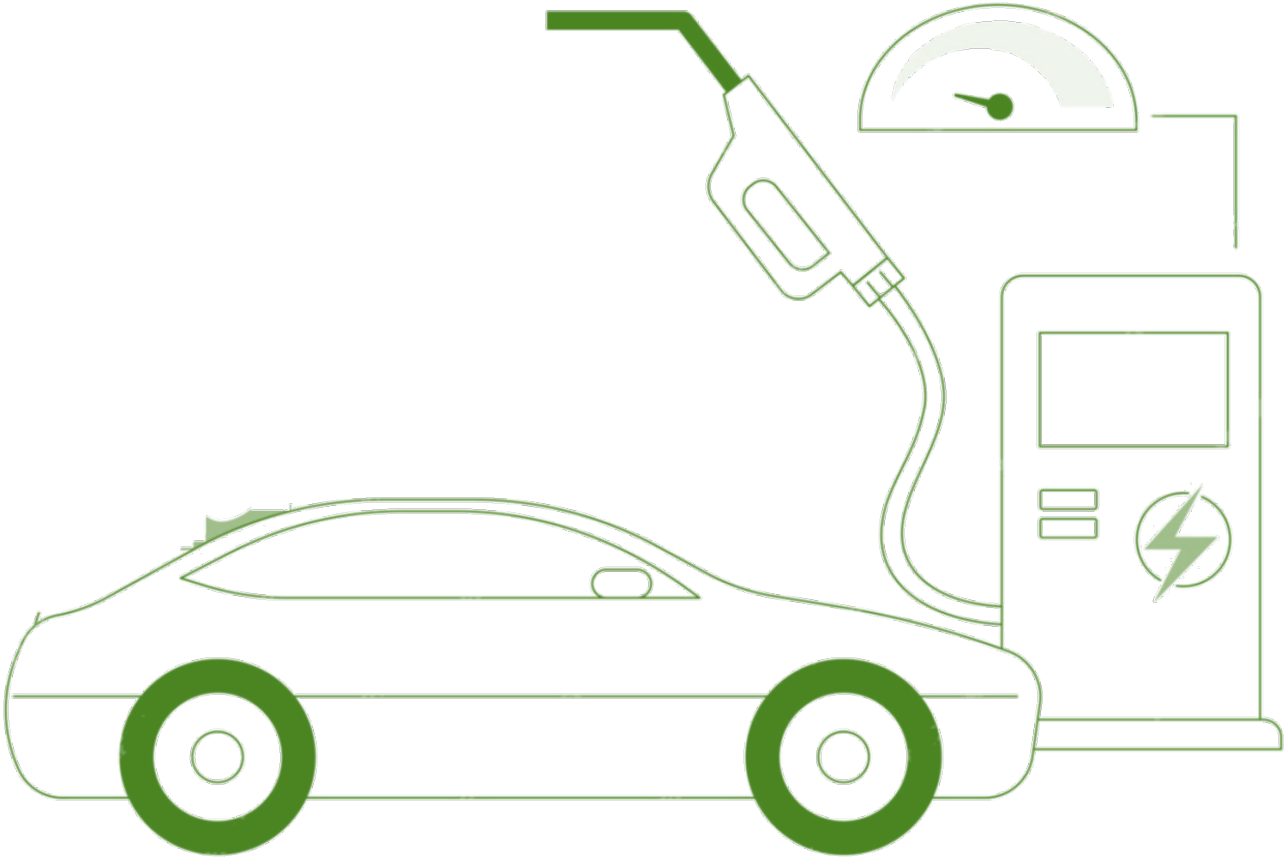
Key trends include the increasing adoption of EVs in emerging markets, technological innovations driving performance improvements and cost reductions, and the expansion of charging infrastructure.

Major players in the EV market include companies like Tesla, BYD and the GAC Group, which have significant market shares. The competition is intense, with various manufacturers vying for market share and innovation. The EV market has evolved significantly over the years, with early adopters like Norway and China leading the charge.

Global EV sales trends show a steady increase, with annual sales expected to reach 30 million units by 2030. The market share of EVs in new car sales is expected to reach 20% by 2030. Charging infrastructure developments are crucial to support this growth, with governments and companies investing in expanding charging networks.

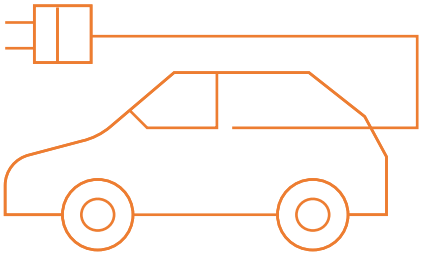
Financial aspects and affordability are critical factors in the adoption of EVs. While the initial cost of EVs remains a significant barrier, cost reductions and incentives are helping to make them more accessible. Governments are implementing policies to promote EV adoption, such as tax exemptions and reduced charging costs.

In conclusion, the global EV landscape is poised for significant growth, driven by technological innovation, cost reductions, and supportive policies. As the market continues to evolve, it is essential to monitor charging infrastructure developments and financial aspects to ensure the widespread adoption of EVs, ultimately contributing to a more sustainable transportation future.



Section 03

PAKISTAN EV LANDSCAPE



Pakistan's electric vehicle (EV) landscape is still in its nascent stages, but there are promising signs for future growth and development. Pakistan embarked on its journey towards formulating an EV policy during 2016 – 2017. A significant milestone was reached in 2019 with the introduction of the draft National Electric Vehicle Policy (NEVP), which was officially adopted in 2020. This pioneering policy outlined ambitious targets for EV adoption and introduced various incentives for manufacturers, including a one percent custom duty and sales tax exemption for locally assembled EVs. Integrated into the Auto Industry Development and Export Plan (AIDEP 2021-26), the NEVP aimed to catalyze the country's transition towards sustainable mobility. However, despite the array of incentives provided, the transition to electric vehicles in Pakistan faces a myriad of challenges. While this shift is imperative for environmental preservation and economic advancement, numerous policy and practical hurdles must be overcome.

Overall, Pakistan's EV landscape is evolving, driven by government support, investments, and partnerships. However, there is still much work to be done to overcome challenges and realize the full potential of electric vehicles in the country.

3.1 Pakistan's Automobile Sector

As per the Economic Survey of Pakistan 2022-23, the automobile sector in the country contributes approximately 4% to the Gross Domestic Product (GDP) and constitutes around 15% of the 'Large Scale Manufacturing (LSM) sector, making it a significant contributor to industrial output and capable of meeting domestic automobile demands. It is also a major revenue generator and job multiplier. Over the past four decades, the country has developed a strong engineering base with investments from international brands and technology transfers.

The auto vehicles market is typically divided into three broad categories:

Cars, Jeeps, and Light Commercial Vehicles

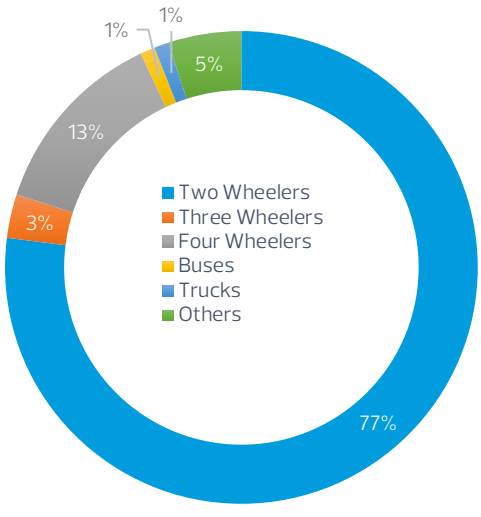
Trucks, and Busses

Tractors, Two and Three Wheelers

Of the above, two-wheelers dominate the numerical count and account for 77% of the total. The next category is Cars at 5% and three-wheelers at 3%. Similarly, the total share of buses and trucks in the total registered vehicles is around 1.6%. The heavily skewed production shows the potential in auto sector in Pakistan favour of two-wheelers. The prime reason for the disparity is the limited purchasing power of the masses. It also highlights an untapped market segment between the 2W and standard car segments.

There has been consistent growth in almost all segments of the country's automobile sector

Registered Vehicles



Economic Survey of Pakistan 2022-23

except in the last 2-3 years where there has been a decline mainly owing to an economic downturn, inflation, PKR depreciation and other factors.

As per the same survey, a total of 34.9 million vehicles are registered in Pakistan as of September 2022, which includes 26.9 million 2-wheelers, 1.0 million 3-wheelers, 4.5 million 4-wheeler passenger cars and 0.6 million buses and trucks.

3.1.1 Present Situation of the Sector

The Economic Survey 2022-23 discloses that, with the exception of buses, there has been a significant decline in the productivity of all sectors of the automobile industry during FY2023 as compared to the previous year. The decline in growth was primarily attributed to the import restrictions on the automobile industry, considering automobiles as luxury items, with the aim of reducing the current account deficit.

In May 2022, the State Bank of Pakistan (SBP) imposed restrictions on the auto industry, requiring prior permission for the import of raw materials and crucial parts- Complete Knock-Down (CKDs) kits needed for local manufacturing of automobile parts. The government initially allowed the industry to operate at about 50% of production capacity until foreign exchange constraints eased. However, with the deteriorating situation of Pak-rupee exchange rate the restrictions on auto imports persisted, which in turn severely impacting the growth of the industry. As a result, the industry's size almost halved resulting in substantial revenue loss for the government and significant job losses in the industry.

There were additional contributing factors as well. The policy rate, which was at 10% in 2022, gradually increased to the present rate of above 20%. During this time, the value of the Pakistani rupee continued to decline and inflation continued to soar. As a result, auto financing became more expensive, and inflation also drove up the prices of automobiles, dampening demand in the market due to reduced disposable incomes. Furthermore, the industry faced challenges due to the upward revision of sales tax, capital value tax, and withholding tax rates.

Category	Installed Capacity	# of Units		
		2021-22	2022-23	% Change
		July-March	July-March	
Car	341,000	166,768	87,820	-47.3
LCV/Jeep/SUV/Pickup	52,000	32,341	25,938	-19.8
Bus	5,000	459	606	32.0
Truck	29,000	4,455	2,677	-39.8
Tractor	100,000	41,872	22,626	-46.0
2/3 Wheelers	2,500,000	1,389,027	925,943	-33.3

Source: Pakistan Automotive Manufacturer Association (PAMA)

Despite the issuance and the implementation of the 2020 EV policy, the adoption of electric two- and three-wheelers in the Pakistan remains low. The main reasons behind this are the inability of the local electric two- and three-wheeler industry to satisfy technological and commercial requirements of the EV market, the high upfront cost of electric two- and three-wheelers which is due to the excessive reliance of the current EV industry on the import of EV-specific

components of the drivetrain. With the absence of reasonable financing options, the purchase price of EVs is beyond affordable limits for most of the prospective buyers. In addition, with limited charging infrastructure, range anxiety remains a valid concern amongst EV users.

a) Two Wheelers

As per a United States Agency for International Development (USAID) report, 'Pakistan: Electric Vehicles and Batteries Market Assessment', in August 2021, there were almost 22 million two-wheelers in Pakistan, mostly ICE, manufactured by over 100 mostly indigenous companies. Almost 99% of the two-wheeler market comprises the following three vehicle categories based upon engine capacity: 70cc, 100cc, and 125cc. Vehicles in these categories have a minimalistic design and offer only essential features to keep the purchase price low. A key trait of the two-wheeler market is that all vehicles belonging to a particular category have almost identical parts, components, chassis, and outlook. All parts and components are supplied locally through a uniform supply chain.

The sales of two-wheelers and three-wheelers witnessed a major dip by 34.8% from 1,820 k units in FY2022 to 1,180 k units in FY2023. Atlas Honda was the market leader in the two-wheeler segment; however, its sales decreased to 1,005 k units in FY2023 from 1,360 k units in FY2022 showing sales decrease of 26.1%. Suzuki was the second largest player in the two-wheeler segment, as it sold 29.2 k units in FY2023 as compared to 37.8 k units in FY2022.

b) Three Wheelers

The three-wheelers are a prevalent mode of transportation for commercial purposes in Pakistan. Presently, there are close to one million three-wheelers manufactured by over 45 automobile manufacturers. There are two types of three-wheelers: passenger transport vehicles and loaders (used for last-mile freight delivery). The three-wheelers of each type share similar design, parts, components, and engine ratings. Almost all three-wheelers used for passenger transport have an engine capacity of 200-250cc, while the three-wheeler loaders typically have an engine capacity of 150-200cc. All three-wheelers carry a minimalistic design, offering essential features only. The local automotive parts industry for three-wheelers has achieved sufficient maturity. Almost all parts except the engine used in the three-wheelers are developed by indigenous Original Equipment Manufacturers (OEMs), resulting in lower upfront cost.

Qingqi is the market leader in the three-wheeler segment, as it sold 6.3 k units in FY2023 down by 54.8% from 13.9 k units in FY 2022. Sazgar was the second largest player in the three-wheeler segment whose sales decreased from 15.6 k units in FY2022 to 9.3 k units in FY2023.

The two- and three-wheeler manufacturers can address the barrier of high upfront purchase price of EVs through offering retro fit services. A retrofit kit for the two-wheeler consists of a battery pack, an electric motor, and associated electronics. A typical ICE-based two-wheeled vehicle can be retrofitted with such a kit and transformed into an all-electric vehicle. This implies that new as well as old ICE-based two wheelers can be converted into EVs through these kits. A typical retrofit kit, consisting of a 2 KWh li-ion battery, a 1,500 Wp motor, and a slow home-based

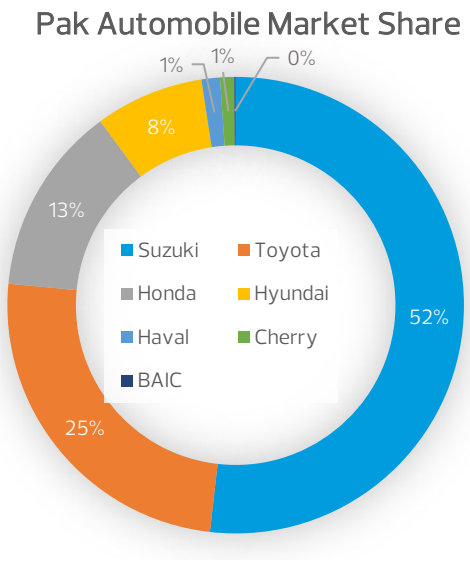
charger, costs almost USD 350. The cost of a retrofit kit for two-wheeler is almost USD 250-350 and provides an alternative to incurring high upfront purchase price new e-vehicles29.

Furthermore, there are opportunities in the development of swappable battery-based three-wheelers. These vehicles address challenges associated with fixed battery-based electric three-wheelers such as longer charging time and higher upfront purchase price, while at the same time reap benefits due to lower operational expense incurred by the electric drive train.

Under the battery swapping regime, the cost of the EV and batteries is separated i.e., the vehicle owner purchases the vehicle without batteries. This brings the cost of the EV at par with their ICE-based equivalents. The vehicle owner/driver obtains the batteries on rental basis from a network of battery swapping stations. As the batteries deplete due to the usage of the vehicle, the three-wheeler approaches a battery swapping station where depleted set of batteries are replaced with fully charged ones and the whole process of battery swapping can be completed in less than 10 minutes. The batteries under this model are owned by the charging services providers and not the vehicle operator.

c) Four-Wheeler Passenger Cars

Most of the ICE-based car market in Pakistan is dominated by international companies having manufacturing facilities in Pakistan that are often established through partnerships with indigenous companies or business groups. Major international players in this market include Toyota, Suzuki, Kia, Hyundai, Honda, MG, Changan, BAIC, Proton, FAW, Prince, DFSK, United and others. Almost all luxury vehicles are imported into the country from companies such as BMW, Audi, Mercedes and Porsche among others. The vehicles' engine capacities in this segment typically range from 660cc – 3500cc. This ICE-based vehicular market has little or no commonality with electric counterparts as most companies are designing new vehicle models for their EV fleet.



Source: VIS Credit Rating Company, Sector Report

As per a sector study by JCRVIS in 2023, all segments of Pakistan Automobile sector were hit by the economic downturn in the country. The passenger car segment was the severely hit among all segments of automobile as its sales plummeted more than half from previous year. The sales of passenger cars reduced from 234.2 k units in FY2022 to 96.8 k units in FY2023 which is a 58% decrease on a year-on-year basis. In the 1300 cc and above passenger car category, sales decreased from 104.3 k units to 44.5 k units.

[29] Indigenization of EV value chain in Pakistan for two and three wheelers, 2024- LUMS

d) Light Commercial Vehicles (LCVs) & Heavy Travelling Vehicles (HTV's)

In Pakistan, a few companies have established local manufacturing of HTVs like Hino, Isuzu, Nissan, etc. Similarly, a few companies develop LTVs in Pakistan like Toyota, Hyundai, JW Foreland, Changan Master Motors, Al Haj FAW, etc. Despite the availability of local manufacturing facilities, most buses are imported into the country, while most medium-sized trucks are manufactured indigenously.

As per the VIS report, in the LCV, sales decreased from 17.5 k units in FY2022 to 5.8 k units in FY2023. Suzuki Ravi experience massive dip in sales as its sales decreased from 14.2 k units in FY2022 to 3.8 k units in FY2023. Hyundai Porter sales also decreased from 1.8 k units in FY2022 to 1.3 k units in FY2023.

In the Bus segment, sales didn't decrease much and stood around 650 units in FY2023 as compared to about 700 units in FY2022. However, in the Truck category, sales fell from 5.8 k units in FY2022 to 3.2 k units in FY2023. Hino Motors witnessed a decrease in truck sales from around 900 units to about 600 units, while its bus sales increased from around 150 units to about 250 units approximately. Master Motors experienced a decrease in both truck and bus sales, from 1.7 k units to around 950 units and 42 approx. 400 units to around 250 units, respectively.

3.2 The Electric Vehicle (EV) Segment of Pakistan

The EV penetration of Pakistan is still under 1% and a lot of work needs to be done if we want to achieve the ambitious EV penetration targets set out in the EV Policy.

3.2.1 Two-wheeler EVs

As per estimates, under 1,000 EV two-wheelers were registered locally in year 2023. Around 100 two-wheelers are being produced in Pakistan every month which are expected to go to 4,000-5,000 in the next few months, based on opinion of Industry experts.

As mentioned above, around licenses for 2-W and 3-W EVs have been granted in the last few years. The major EV players include Jolta Electric, Pak Zone, Metro, Zyp Technologies, Vlektra, Nova Mobility, Road Prince, MS Jaguar, Crown etc. A list of notable 2W EV brands In Pakistan are listed in Annex 2. The following table shows the key characteristics of the current two-wheeler variants developed in Pakistan.

Characteristics	Values
Purchase Price (USD)	500-1000
Driving range / full charge (km/s)	70-100
Battery capacity (kWh)	1.5-2.0
Top Speed	50-80
Charger compatibility	Level-1 (slow/home-based)
Charging time (hours)	2-4
Motor rating (kW)	1-1.5

Source: - LUMS report 2024 titled Indigenization of EV value chain in Pakistan for two and three wheelers

The local 2W EV producers/ assemblers are expected to have tough competition from foreign franchises like Honda with huge marketing budgets, larger scales of production, tried & tested

products and greater brand equity, perceived reliability and quality. However, these local players need to play on their advantages such as early mover advantage, lesser fixed costs, niche target market focus, faster decision-making, opportunity to establish their respective brands based on high quality, reliability, excellent after sales, easy availability of spare parts, various sales models such as battery swapping, establishing partnerships with financial institutions and B2B clients, flexibility of outsourcing segments of manufacturing etc.

3.2.2 Three-wheeler EVs

The 3-wheeler EV segment would target the working class or the lower income segment of society who rely on driving 3-wheelers/ rickshaws as their main source of income. A typical rickshaw driver works almost every day, taking a day off only when circumstances such as illness or other unavoidable events compel them to. Their daily earnings are vital for covering their everyday expenses.

The Engineering Development Board (EDB) has reportedly granted over 40 EV production licenses in Pakistan, mostly to two and three-wheeler manufacturers/ assemblers. The major players in 3W EVs in Pakistan are Sazgar Autos, Nova Mobility, Daewoo and Neubolt. Daewoo and Neubolt are newer players who plan to launch commercial operations soon but their business model will focus not on selling but owning and operating 3W commercially. Sazgar Autos has been one of the most notable 3W rickshaw production brand In Pakistan, is listed on the Pakistan Stock Exchange and makes chassis for almost all other 3W EV producers such as Neubolt, Nova and Daewoo. A list of notable 3W EV brands In Pakistan are listed in Annex-2.

The following table shows the key characteristics of the current three-wheeler variants developed in Pakistan.

Characteristics	Values
Purchase Price (USD)	3,000 – 4,500
Driving range / full charge (km/s)	80 - 150
Battery capacity (kWh)	5 - 12
Top Speed	40 - 70
Charger compatibility	Level-1 (slow/home-based)
Charging time (hours)	2.5-5
Motor rating (kW)	3-5

Source: - LUMS report 2024 titled Indigenization of EV value chain in Pakistan for two and three wheelers

3.2.3 Four-wheeler passenger EV Cars

Due to the need for higher degree of technological advancements for indigenous development required for cars, there are currently no local players in the market for electric car manufacturing. As per a report by the United States Agency for International Development (USAID), in 2021 there were almost 2,000 electric cars in Pakistan and all of them were imported, and there were around a dozen fast charging stations dedicatedly developed to serve the fleet of electric cars.

As per a report by the Pakistan Business Council, titled 'Electric Vehicles: Make in Pakistan Perspective' published in June 2023, EV kits are approximately 80% more expensive than their ICE counterparts. EV prices range from $18,000 to $30,000, while ICE vehicles are priced around $15,000. Percentage-based taxes further contribute to a significant increase in the end-user

price, with the typical tax on a finished car reaching nearly 45% of the price. However, the current tax regime includes exemptions for EVs that offer attractive options to reduce prices for end users.

As per Pakwheels, the top automobile web-based marketplace in the country, major EV 4-wheelers available in the country include:

Company	Varlant	Battery Capacity (kWh)	Price (PKR Mn)
Audi	e-Tron	106.0	42.0-51.0
	e-Tron GT	93.4	58.0-81.0
MG	MGZS EV	51.1	13.0-15.0
	MG4 EV (Excite51 & Essence64 variants)	51.0/64.0	11.0-13.0
	MG5 EV	61.1	13.5
Hyundai	Ioniq5	72.6	22.5
	Ioniq5	77.4	23.0
BMW	i3	42.2	NA
	i4	83.9	30.0-42.0
	I5	83.9	NA
	iX (xDrive40 & xDrive variants)	71.0/105.2	40.0-54.0
	i7	101.7	NA
DFSK	Series 3		8.3
Sazgar-GWM	ORA03	47.8	9.0
Gugo	Gigi		4.6

Source: www.pakwheels.com

Moreover, we have seen recent media coverage of prototype release of first locally-manufactured 4W EV of Pakistan, Nur-E 75 by DICE Foundation, a US-based non-profit organization of Pakistani-American motor engineers, however, ts commercial launch Is still awaited.

3.2.4 LCVs & HTVs

There were 150 Golden Dragon Plug-in Hybrid Electric Vehicle (PHEV) buses in Pakistan that were in operation at Bus Rapid Transit (BRT) corridor in Peshawar in 2021. Sapphire Electric collaborated with the Government of Sindh on introducing BYD electric buses in Karachi. Recently, Hitachi ABB Power Grids has entered into an agreement with Chinese electric bus manufacturer, Skywell and one of the largest bus operators in Pakistan - Daewoo to provide an electric bus solution.

Till date, there is no manufacturing/assembling facility for electric buses and all buses are being imported.

3.3 EV Charging Infrastructure

The electric vehicles and charging infrastructure connection is somewhat like a chicken-and-egg-story - for commercial charging stations to cross their breakeven and make economic sense, it is important that there are adequate vehicles that are available to be charged at them. Similarly, if

there are not enough charging stations available, the chances of range anxiety creeps in, resulting in slower EV adoption. However, we also need to keep in mind that the capital expenditure for fast charging stations is significant, not to mention their high operational costs. The cost of high-quality fast chargers' ranges from USD 12,000 to USD 65,000 each depending on the capacity and make of the chargers – the prices reduce for some Chinese charger options, but the reliability and quality are also then compromised.

3.3.1 2-Wheelers

For 2-wheelers, there are presently no commercial-scale charging facilities available in Pakistan except in a few Business-to-Business (B2B) instances where the EV manufacturers have provided fast chargers to businesses which are placed at hubs to charge their employees' EV bikes. Examples include food delivery and courier services. All 2-wheeler manufacturers provide a slow home-based charger with each vehicle, which can take up to 8 hours to completely charge the battery and provide a 60-100 km driving range. A battery swapping charging model is also being introduced by a few vendors, which will be discussed later in the report.

3.3.2 3-Wheelers

The 3-wheelers in the country, especially those working commercially, have much longer daily commutes than private vehicles and therefore, they have higher battery capacities. Like 2-wheelers, the 3-wheelers also come with home-based charging solution – it takes around 8-10 hours to completely charge current models of electric three-wheelers using slow home-based chargers. The battery swap model is being considered by many vendors, being a very viable option for this segment.

3.3.3 4-Wheelers

The home charging option remains available with the EV 4-wheelers presently being offered in Pakistan - all vehicle sales are accompanied by home chargers which are usually installed on walls at homes. Some car owners pay extra to buy even higher quality chargers of top brands like ABB and Star Charge to replace the chargers accompanying their vehicles since affordability is not a big issue for most of the present social class owning imported 4-wheeler EVs.

Due to the absence of enough EVs in the country, there are very few market players that are presently offering fast charging services. There are around a dozen commercial fast charging stations in the country at the moment, mostly on motorways and large metro cities. The installed charger ratings are between 50 to 350kW. The same chargers are capable of charging other vehicle segments too like LCVs, trucks and buses when required.

3.4 EV Parts Supply Chains

Pakistan has a mature and well-established industrial base for ICE automotive parts and components manufacturing. As per a report from the Pakistan Credit Rating Agency (PACRA), there are approximately 1,200 auto parts vendors in Pakistan, out of which around 250-300 vendors belong to Tier-1 category and are suppliers for the Original Equipment Market (OEM) which are registered with the local auto parts association, the Pakistan Association of Automotive Parts & Accessories Manufacturers (PAAPAM), formed since 1988. The localization levels (proportion of parts manufactured locally) of passenger cars & LCVs are 50-60%, of trucks/ buses at 30%, tractors at 85% and motorcycles at 90%.

Presently, most EV producers are either importing their batteries from China or other countries or importing battery cells and assembling batteries themselves. For motors, import is an option, but a few are also purchasing motors from local electric fan manufacturers with motor production capabilities. Motor manufacturing mainly takes place in Gujranwala and surrounding areas in Pakistan. Recently, the industry has commenced manufacturing of BLDC motors which are used in a wide range of applications such as water pumps and electric fans. However, the motor industry in Pakistan primarily develops low-power products with rating of up to 10KW. These motors typically deliver low rpm (1,500-3,000) and are thus not suitable for EV applications that require high output that is often to the tune of 10,000 rpm. Furthermore, most of the locally developed motors are efficient up to 80% and hence are not worthy for EV applications that require up to 95% efficiency. The current production process also mostly relies on recycled materials; the electric steel sheets are mainly recovered from international scrap. Furthermore, since manufacturing of original copper wire requires scale, so secondhand copper wires are used in manufacturing of motor winding.[30] Most of the other components including body structures and IT support is being sourced locally.

With the advent of EVs in Pakistan, it is expected that a sizeable market for EV-related parts and components will emerge. Presently, there are no Pakistan-based OEMs offering EV specific solutions. For EVs, the supply chains will gradually develop with more focus on areas different from traditional auto supply chains. The new areas would include capabilities in battery technologies, electric motors, energy, AI/IoT/ cloud computing, lighter body materials etc.

3.5 EV Policy & Regulation

The Government of Pakistan introduced and approved the Electric Vehicle & New Technology Policy 2020-2025 in April 2020, which aims at promoting non and low hydrocarbon-based technologies for transportation purposes through incentives for end-users and manufacturers. The policy aims to reduce emissions from the transport sector and create an indigenous industrial base to develop the EV value chain. In contrast to offering direct consumer subsidies, the policy provides rebates, tax breaks, and other concessions to encourage the adoption of environment-friendly vehicles. The policy provides incentives for EVs, HEVs, PHEVs, and alternative fuel vehicles. Vehicular categories addressed by the policy include two-wheelers, three-wheelers, cars, buses, and trucks. Policy incentives are extended to stimulate new investment in the development of next-generation technologies, automotive parts manufacturing, facilitating new entrants in the respective industry, and the development of charging infrastructure. Requisite interventions by relevant government departments/agencies, particularly in developing EV standards, are also highlighted in the policy.

Salient features of the policy are tabulated below:

Description	Vehicle Type	Custom Duty(CD)	GST	+ Incentives
Completely Knocked Down (CKD) – EV Specific Parts Localized CD 25%	Buses & Trucks	1%	1%	0% VAT at import stage
	4W-Vehicles & SUVs	1%	1%	0% Additional Customs Duty (ACD)
	2W Motorbikes & 3W Auto Rickshaw	1%	1%	0% Regulatory Duty (RD)

[30] Indigenization of EV Value Chain in Pakistan for Two and Three Wheelers by LUMS

Non-Localized CD 10%				
Completely Built Unit (CBU)	Buses & Trucks	1%	1%	0% VAT at import 0% ACD 0% RD
	Passenger Vehicles & SUVs	10% till June 2022 & it would increase to 25% till June 2026	1%	
	2W Motor Bikes & 3W Auto Rickshaw	50% of prevailing CD	1%	
Duty- & Tax-Free Import of Plant Machinery of EV Assembly and Manufacturing		0% CD 0% ACD 0% ACD		Income Tax exemption for auto part manufacturers for setting up manufacturing facility for EV related equipment
Import of EV Charging equipment		1%		0% ACD 0% RD

Unit Economics

As per discussions with various EV players, an operational comparison of ICE vs EVs in different segments is summarized below:

ICE Operational Cost				
	2W	3W	4W	Bus
Fuel Cost per Liter (PKR)	288	288	288	288
Kms per Liter (Km)	45	20	9	3.5
Fuel Cost per Km (PKR)	6.4	14.4	32	82.3
Maintenance cost per Km (PKR)	1	2	4	30
Total ICE Cost per Km (PKR)	**7.4**	**16.4**	**36**	**112.3**

EV Operational Cost				
	2W	3W	4W	Bus
Cost per kWh/unit (PKR)	60	60	60	60
Kms per kWh (Km)	35	15	4	1
Cost per Km (PKR)	1.7	4	15	60.6
Maintenance cost per Km (PKR)	0.1	0.2	0.4	12
Total EV Cost per Km (PKR)	**1.8**	**4.2**	**15.4**	**72.6**

Estimated Cost Savings of EV over ICE	**5.6**	**12.2**	**20.6**	**39.7**
	75%	**74%**	**57%**	**35%**

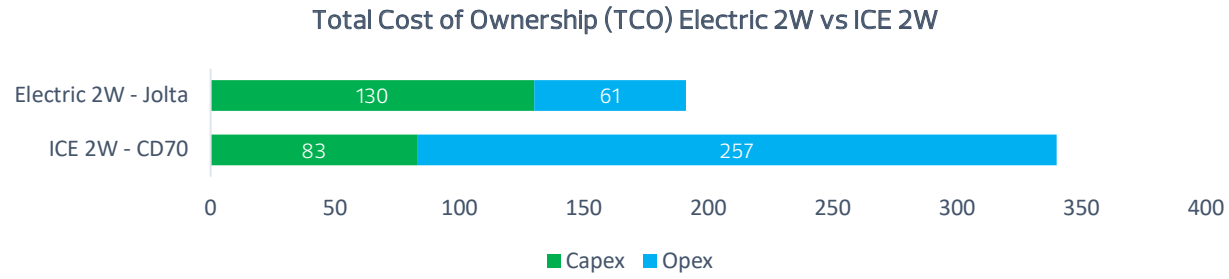
Source: Based on various local and international secondary sources and on discussions with Pakistani EV players

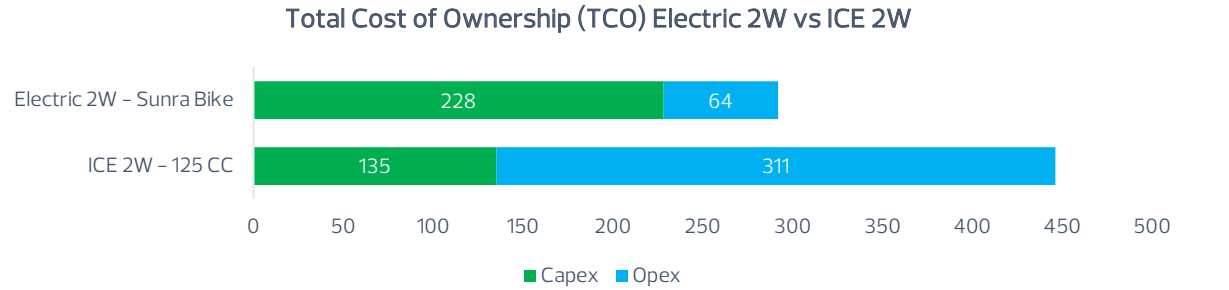
3.6 Total Cost of Ownership (TCO)

A TCO analysis was carried out in a report titled "Scaling Up Electric Mobility in Pakistan" by 'National Energy Efficiency & Conservation Authority (NEECA)' in October 2021. The analysis was done for a 5-year period for 2W, 3W and 4W passenger vehicles and 10-year period for buses. Two fundamental cost aspects were considered for this analysis i.e. the capital expenditure (CAPEX) which refers to the upfront investment/ purchase cost and the operational expenditure (OPEX) which covers the cost of operations, maintenance and fuel over the considered time period. The TCO values are In PKR thousands.

Since then, there has been a considerable increase in the upfront costs of both ICE and EV vehicles, and also the operational costs including fuel costs – the only decrease was perhaps in the technology costs especially the battery cost (the major component of the EV cost). Therefore, if both the ICE and EV costs increased by same proportion, the analysis still gives a fair comparison.

3.6.1 2-Wheelers

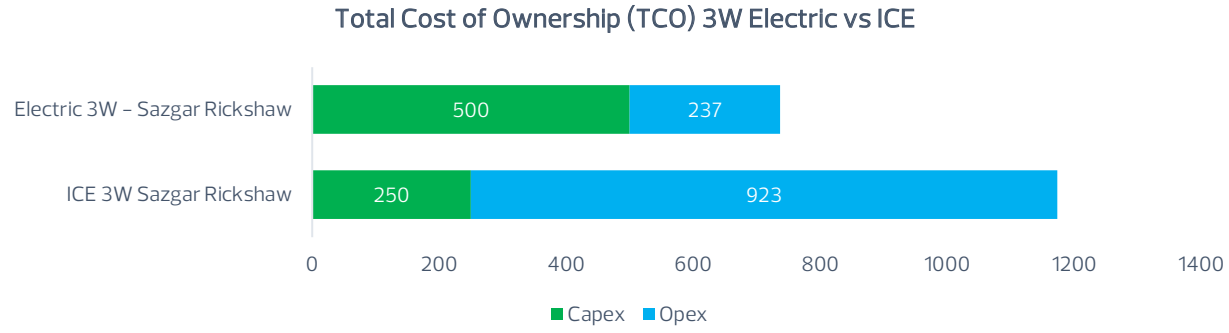




The above comparisons were made between the most popular motorcycle variant in Pakistan, the 70cc and the higher end variant of 125cc with their closest available counterparts in EV space. This TCO comparison demonstrated that electric two-wheelers are economically competitive for both personal and commercial use, which is achieved at 50+ km daily usage. While the upfront cost in the case of a 2W is 50-75% higher than the ICE equivalent, but the operational cost per Km is almost 50% lower than that of an ICE 2W.

As per present fuel and electricity prices, and based on the unit economics table given earlier in this chapter, the annual average cost saving of a 2W EV over a similar ICE variant, calculated at a daily travel of 50 km and 300 operating days per annum, comes out to be PKR 84,000 per year.

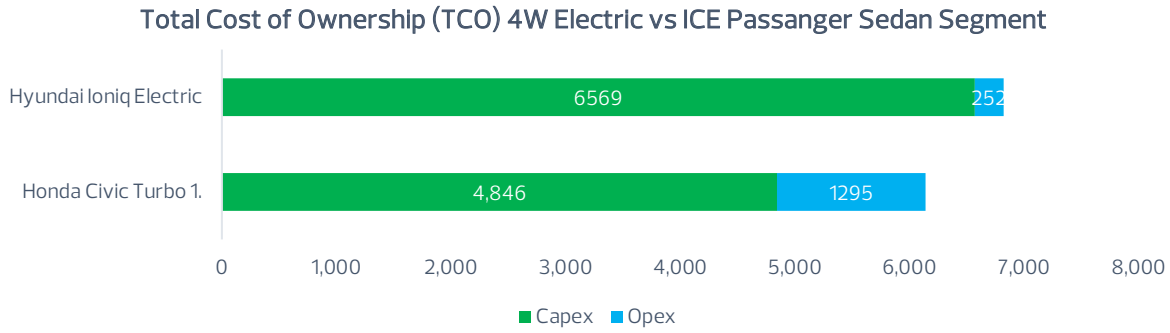
3.6.2 3-Wheelers



The TCO comparison in auto-rickshaw segment indicated that electric-rickshaw was at TCO parity with ICE equivalent. While the upfront cost in the case of electric 3W is about 100% higher than ICE rickshaw, the e-rickshaws have a lower TCO, if daily running is more than 100 km. For an average daily usage case of 100 km, the TCO of e-rickshaw is 37% lower than ICE equivalent.

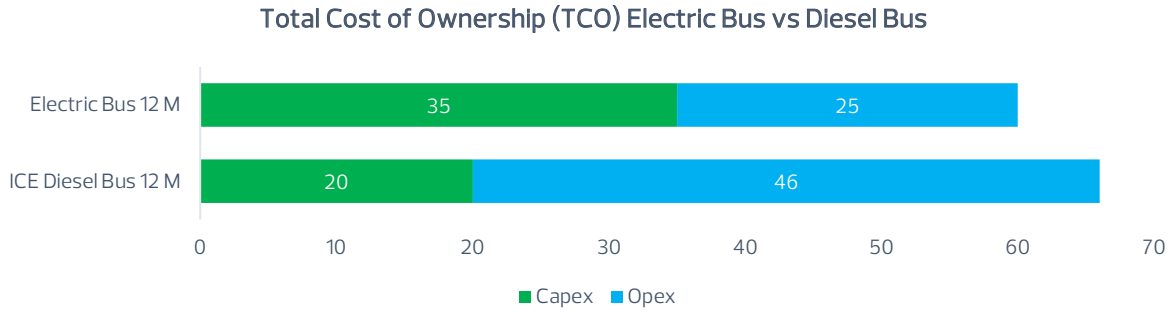
On an average, a rickshaw drives daily for over 200 kilometers and 250 kilometers in Lahore and Karachi respectively. With existing lithium-ion battery pack, Sazgar eRickshaw has a range of over 125 km.
As per present fuel and electricity prices, and based on the unit economics table given earlier in this chapter, the annual average cost saving of a 3W EV over a similar ICE variant, calculated at a daily travel of 150 km and 300 operating days per annum, comes out to be PKR 550,000 per year.

3.6.3 4-Wheeler Passenger Cars



Electric cars can be economically viable for commercial fleet operations but TCO equation is not yet attractive for personal use case. TCO analysis demonstrates that electric cars are economically viable for commercial fleets with high daily utilization. Comparing Hyundai Ioniq Electric with Honda Civic 1.5 Turbo in premium sedan car segment, a TCO analysis indicates 14% higher TCO for electric variants.

3.6.4 Buses



Electric buses have a very high upfront cost differential due to the large size of the battery. TCO parity can be achieved at the daily usage of over 250 km. However, we believe that the adoption in buses would be based on support from government driven demand in the form of additional purchase subsidies and not on TCO parity. For electrified public transport fleets to be economically competitive, electric buses would need higher utilization to lower capital costs.

3.7 Conclusion

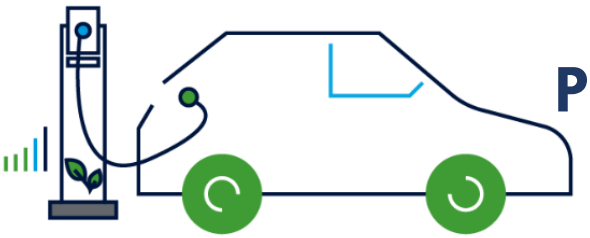
The Pakistani automobile sector is expected to witness a significant shift towards EVs in the coming years, to be driven by the Government's ambitious National Electric Vehicles Policy (NEVP) and the growing demand for sustainable transportation solutions.

The sector is dominated by two-wheeler manufacturers, such as Vlektra, Jolta, and Sazgar Engineering Works, which have emerged as key players in the EV landscape. Four-wheeler manufacturers are also gradually adopting EVs, with some announcing plans to expand their EV lineups. Electric buses and motorbikes are becoming increasingly common on Pakistani roads. However, the development of a robust EV charging infrastructure remains a challenge.

The local EV parts supply chain is still evolving, and policy and regulatory frameworks need to be refined to support the growth of the EV sector. Despite these challenges, the EV unit economics in Pakistan are attractive, with lower operating costs and environmental benefits.

As the country aims to moves towards a greener future, the EV landscape in Pakistan is poised for continued growth and innovation, with lifetime comparisons with ICE equivalents indicating significant environmental and economic benefits.

Section 04



PERICULA EV ADOPTION

In the endeavor to embrace Electronic Vehicles (EVs) on a global scale, a myriad of risks and challenges emerge, underscoring the complexities inherent in this transition. At the forefront lies the persistent hurdle of cost, with the initial investment in EVs often outweighing that of conventional vehicles—a deterrent for many prospective buyers, especially in economically constrained environments. Concurrently, concerns surrounding range anxiety and charging infrastructure loom large, casting shadows of uncertainty over the feasibility of widespread adoption. While advancements continue to extend the range of EVs and enhance charging technologies, disparities in infrastructure development persist, particularly in regions with limited access to charging stations. Moreover, the time-intensive nature of charging EVs, even with rapid charging options, poses practical challenges that may impede adoption, particularly in bustling urban centers where time is of the essence.

In the narrative of EV adoption, developing countries stand as pivotal actors facing unique hurdles and opportunities. While the risks and challenges are abundant, so too are the prospects for transformative change. By leveraging innovative financing mechanisms, embracing scalable infrastructure solutions, and fostering strategic partnerships, developing countries can navigate the complexities of EV adoption while simultaneously addressing pressing environmental and economic imperatives. Through collaborative efforts that prioritize inclusivity, sustainability, and resilience, developing nations can chart a course towards a future where electric mobility serves as a catalyst for progress, prosperity, and shared well-being on a global scale.

As reported by netsoltech, EV adoption is predominantly led by global powers such as China, the United States, and key European nations including Germany, Norway, and the United Kingdom. These countries have witnessed a rapid increase in EV sales in recent years. However, netsoltech highlights that despite this global trend, developing countries face numerous hurdles in embracing EVs. Factors such as lower purchasing power, inadequate infrastructure, economic instability, and a lack of supportive environments pose significant barriers hindering EV adoption in these regions. Additionally, the masses in developing countries, with limited purchasing power, are less likely to consider environmental concerns while making their purchase decisions.

The following section highlights some of the bottlenecks faced by the EV industry in developing countries, particularly Pakistan.

4.1 Government Regulations and Policies

Inconsistent government policies and the gaps between policy and its actual implementation create a climate of uncertainty for consumers and manufacturers alike and pose a challenge to investments in EV infrastructure and technology. The capacity building of the policy makers is also very important to guide policy efforts.

In Pakistan, the Government has offered meagre and insufficient subsidies/rebates for EVs. These tax incentives are also not well publicized and explained, making it difficult for people to understand and take advantage of. Resulting from minimal regulatory oversight, substandard products have made inroads into the Pakistani market. These products fail early and often, creating a negative perception of the technology in the consumer mind, delaying market penetration. The regulatory environment must be accommodating for local assembly and manufacturing infrastructure that needed to be fostered and sustained.

Although, Pakistan adopted an EV Policy in 2020, as per discussions with different stakeholders, the incentives are not enough to trigger EV growth in the country in line with Pakistan's ambitious targets.

4.1.1 Technological Challenges

In developing countries like Pakistan, the market opportunity in the 2-wheeler and 3-wheeler segments offers a solution for consumers who cannot afford more expensive four-wheelers[31]. Logistics companies (like TCS and DHL) and ride-hailing companies (like Careem, Uber) can play a role in EV adoption as they can overcome challenges comparatively easily as compared to individuals. However, electric motorcycles have been facing challenges in the ride-hailing segment because the passenger weight and speed significantly reduces range and battery performance also deteriorates over time, leading to performance uncertainty. Similar feedback has been reported from Pakistan, Indonesia, and India[32].

4.1.2 Missing Economies of Scale

One of the core challenges for EV adoption in developing markets is the missing economies of scale. The Pakistani market is rather small – the top selling ICE car in Pakistan, Toyota Yaris, had

[31] Electric Vehicles: Make In Pakistan Perspective, The Pakistan Business Council

[32] https://www.brecorder.com/news/40292113

an annual production of 32,696 in 2023 globally, while in the same period Tesla Model 3 sales were 1.23 million units. A clear Minimum Order Quantity (MOQ) would reduce uncertainty and enable long term supply chain planning. With firm bulk orders planned and placed – competitive pricing will be achieved, lowering the overall cost of the car.

4.1.3 Grid Integration and Capacity

Once the EV market grows, the risk of overloading of local grids due to simultaneous EV charging increases substantially. Therefore, a careful load management plan needs to be in place in terms of grid upgrades and load management solutions to ensure the transition to EV is as smooth as possible. Some off-grid solutions such as commercial solar Installations etc. may provide an alternative solution especially for the EV charging Infrastructure on highways, however, limited space and energy supply disruptions during non-sunlight hours are major challenges. Similarly, for urban charging stations, there will have to be a major dependence on the grid at least for transmission from remote solar or wind power sites through wheeling.

4.1.4 Testing and Certification Requirements

Stringent testing and certification requirements for EVs poses a challenge for manufacturers looking to enter the Pakistani market. Presently, testing labs that certify vehicles are not setup in the country. Thus, compliance with international safety, performance, and emissions standards adds to the cost and complexity of bringing EVs to the market. Thus, many companies either develop sub-standard vehicles for local market or introduce imported vehicles from China instead of investing in the development of the EV value chain in Pakistan.

4.1.5 Standardization

The lack of uniformity in charging connectors, protocols, and communication interfaces is a challenge that could hinder interoperability. Therefore, a gradual standardization plan should be in place which encourages coherence but avoids adversely impacting any business models such as battery swapping mechanisms.

4.1.6 Skilled Workforce for EV Maintenance

The shift to EVs requires specialized maintenance and repair skills. EV buyers face challenges in finding skilled workforce in batteries, high-efficiency motors, and power electronics. This is partly due to the lack of sufficient funds to leverage the required HR. There is no repair ecosystem available, and drivers would have to return the bike to the vendor for minor repairs, leading to significant downtime and increase in maintenance expenditures.

A good understanding of battery technology, electric power engineering, EV charging standards, Infrastructure design and proficiency in data analytics, machine learning, and telematics systems are all valuable skills that are currently in short supply.

4.1.7 Supply Chain and Manufacturing Constraints

Developing countries like Pakistan face challenges in establishing a robust supply chain for EV components and in setting up local manufacturing facilities. These challenges can lead to dependencies on imports, making EVs less competitive. To make EVs successful local manufacturing of battery packs and motors is critical. To manufacture any of these, governments need to announce favourable policies regarding the import of required raw materials. With low

initial volumes of EVs in developing countries, currently there is incentive for any parts manufacturer to explore EV parts manufacturing.

4.1.8 Cost of Charging Infrastructure

Just like the EVs vehicle, there is a high cost linked with setting up of charging infrastructures too for companies. One solution may be that there are separate business players for setting up, owning and operating commercial charging infrastructures than the EV manufacturers, however, a close coordination is required by both segments.

4.2 Consumer Risks & Challenges

4.2.1 High upfront costs/ Limited Purchasing Power:

An EV is more expensive than an ICE mainly due to the high cost of batteries. In developing countries where purchasing power of the masses is limited, the high upfront cost of an EV (2-3-4 wheelers) as compared to an ICE is often prohibitive. As advancements in battery development technology continue, this cost is expected to come down in the future. The governments should offer financing opportunities, subsidies, rebates, and other incentives to encourage consumers to buy EVs.

4.2.2 Inadequate Charging Infrastructure and Range Anxiety

EVs require a reliable and strong electrical grid to charge the batteries, and many developing countries lack the infrastructure to provide this. In addition, EVs require specialized charging stations, which are often not available in developing countries. This causes range anxiety among people. Even when access to these charging stations is possible, the process of recharging an EV can often be slow and unreliable[33].

In Pakistan, battery swap options for 2-wheelers also have very few charging stations available, and it is very inconvenient for a driver to drive 10-15 km to swap a battery. The savings per swap have been estimated to be PKR 300-350, which currently is approximately equivalent to the cost of a liter of petrol, while ICE bikes achieve around 40 km per liter. InDrive, an international ride-hailing company, with a strong footprint in Pakistan has announced[34] its plan to add electric motorcycles to its fleet in the country. The company is already working on pilot projects in Indonesia and Kazakhstan. The initial findings are that the charging infrastructure is the key, without which it's going to be very hard to scale the electric fleet in any country in any city.

4.2.3 Limited and unfavorable financing options

Owing to lower market demand and uncertain resale value/ less developed secondhand market, access to financing for purchase of EVs is currently limited in Pakistan, as comparison to traditional ICE vehicles, restricting the ability of a significant portion of the population to transition to EVs. Moreover, high-interest rates currently prevailing in Pakistan make vehicle purchase (both ICE and EV) an unattractive option for prospective buyers. In Pakistan, currently a buyer must pay approximately 60-90% over the 2-wheelers bike's price if bought on loan over a period of 2-3 years.

[33] https://netsoltech.com/

[34] https://www.brecorder.com/news/40292113

Developing countries like Pakistan need to improve their ability and capacity to tap the climate financing initiatives available globally. A good example in this case is the Just Energy Transition Partnerships (JETP) introduced by South Africa in 2021- a first-ever, decarbonization program where wealthier nations commit concessional climate finance to a coal-dependent developing nation to support the country's own path to transition towards clean energy. As of March 2023, the donor pool includes the International Partners Group (IPG) and the Glasgow Financial Alliance for Net Zero (GFANZ) Working Group. The IPG consists of Japan, the USA, Canada, Denmark, France, Germany, Italy, Norway, the EU, and the UK. The GFANZ Working Group comprises multilateral and national development banks and finance agencies such as HSBC and CitiBank[35]. South Africa, Indonesia, and Vietnam have already received funding[36] through this mechanism.

4.2.4 Electricity Shortfall and Battery Performance

Many developing countries experience electricity shortfalls which directly impacts EV adoption. In Pakistan, while the grid has enough capacity, revenue-based load management in many localities makes it difficult to operate charging stations. The long charging times and limited driving range per charge add to the perception of EVs as less convenient, contributing to hesitancy in their adoption.

4.2.5 Resale Value of Batteries and EVs

Resale value of the battery is unestablished as second life use cases or a secondary recycling market are yet-to-be established and there is lack of traceability of battery health due to lack of certification standards. Resale value of vehicle without the battery is unknown. Further, a secondary market for used EVs has not been established yet, which increases customer risk.

4.2.6 Limited Model Variety and Availability

The limited availability of EV models in developing countries to suit specific needs, preferences, or budgets compared to traditional vehicles restricts consumer choice. While the Engineering Development Board (EDB) in Pakistan recently granted licenses to 34 manufacturers of such vehicles under the Electric Vehicles Policy for 2020-2025, marking a shift from traditional fuel-powered cars to electric ones, the manufacturers are slow to bring new models into the market.

4.2.7 Additional Capex During Life of Vehicle

EVs, especially 2 & 3Ws, which have a better market in the developing countries, inherently have a different capex structure. The battery needs to be replaced after 4-5 years of running. Given batteries make up 40-60% of the vehicle cost, this is a significant investment required during the life of the vehicle. This adds to the capex burden of the buyer, especially because financing[37] of this capex is currently unclear.

4.2.8 Public Mindset and Awareness

There is a need to shift the public mindset towards EVs and raise awareness about their economic and environmental benefits. There is significant skepticism regarding product performance and technology given its nascency and lack of historic data to gauge durability of product for different applications. There is uncertainty in savings and earnings since higher initial cost is needed against

[35] https://greennetwork.asia/

[36] https://ecdpm.org/.

[37] Driving affordable financing for electric vehicles in India, BSG, ADB, NitiAayog

an income which is contingent on running and usage of EVs[38]. Governments in developing countries should run comprehensive public awareness campaigns to not only familiarize the public on the environmental benefits of EVs, but to also demystify the EV technology for the masses and to better explain the available incentives to encourage people to buy.

Addressing the bottlenecks to EV adoption will require collaborative efforts between the government, financial institutions, industry players, and other stakeholders to create an enabling environment for the EV industry in developing countries. This includes ensuring clear policies, effective implementation, fostering a supportive ecosystem, and exploring avenues to enhance affordability and accessibility of EVs for the masses.

[38] Driving affordable financing for electric vehicles in India, BSG, ADB, NitiAayog

Section 05

EV FINANCING PAKISTAN'S PATH

Electronic Vehicles (EVs) represent a pivotal transformation in the global automotive landscape, offering sustainable mobility solutions and contributing to environmental conservation efforts. In the context of Pakistan, a burgeoning interest in EVs has emerged as the nation strives towards a cleaner, greener transportation ecosystem. Within this landscape, the chapter on "Financing" delves into the intricate financial mechanisms driving the adoption of electric vehicles across Pakistan. This chapter explores the financing models, challenges, and opportunities inherent in facilitating widespread EV adoption within the country.

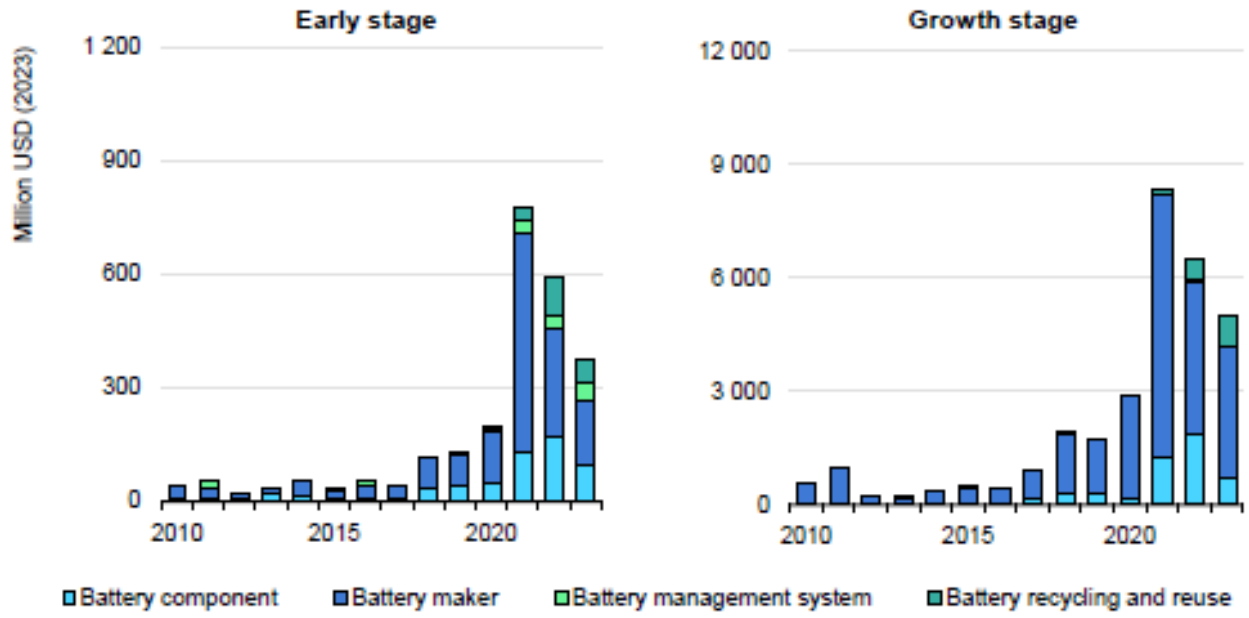
As Pakistan embarks on its journey towards an electrified future, financing plays a crucial role in overcoming barriers and catalyzing the transition to electric mobility. This chapter examines the various financing options available to consumers, businesses, and policymakers, shedding light on innovative approaches and best practices to promote sustainable transportation solutions. From government incentives to private sector investments, the financing landscape for electric vehicles in Pakistan is evolving rapidly, presenting both opportunities and challenges for stakeholders across the industry.

Through an in-depth analysis of financing strategies, this chapter seeks to provide a comprehensive understanding of the financial dynamics shaping Pakistan's EV landscape. By addressing key issues such as affordability, accessibility, and sustainability, it aims to offer insights and recommendations to accelerate the adoption of electric vehicles, paving the way for a cleaner, more sustainable future for Pakistan's transportation sector.

5.1 EV Financing – International

Venture capital (VC) funding for EV start-ups has boomed in the past decade with financial investors such as banks, VC funds and Private Equity (PE) funds seeing a strong potential for significant future returns.

However, in 2023, global VC investments in clean energy start-ups fell considerably relative to 2022, and EVs and batteries were no exception.



Source: IEA Global EV Outlook

5.1.1 Early-Stage Investments

Early-stage investments (i.e. seed and series A) in start-ups developing EV and battery technologies dropped 20% to USD 1.4 billion in 2023, which included USD 400 million in EV charging technology, USD 260 million in battery/ battery component makers and USD 200 million in two- and three-wheeler start-ups. Investors also showed interest in upstream and downstream EV supply chain segments while there was lesser interest for electric cars segment.

The major deals include:

- Germany-based **Jolt Energy's** first round of VC funding of USD 160 million, which seeks to bring its fast-changing technology to urban areas of Europe and the United States, and claims to provide 100 km of driving range in just 5 minutes.
- German EV charging start-up **Numbat** raised USD 75 million in series A funding through the European Infrastructure Fund, as well as another USD 75 million in loans
- Indian start-up **Charge Zone** also raised nearly USD 55 million to develop nearly 300 charging stations

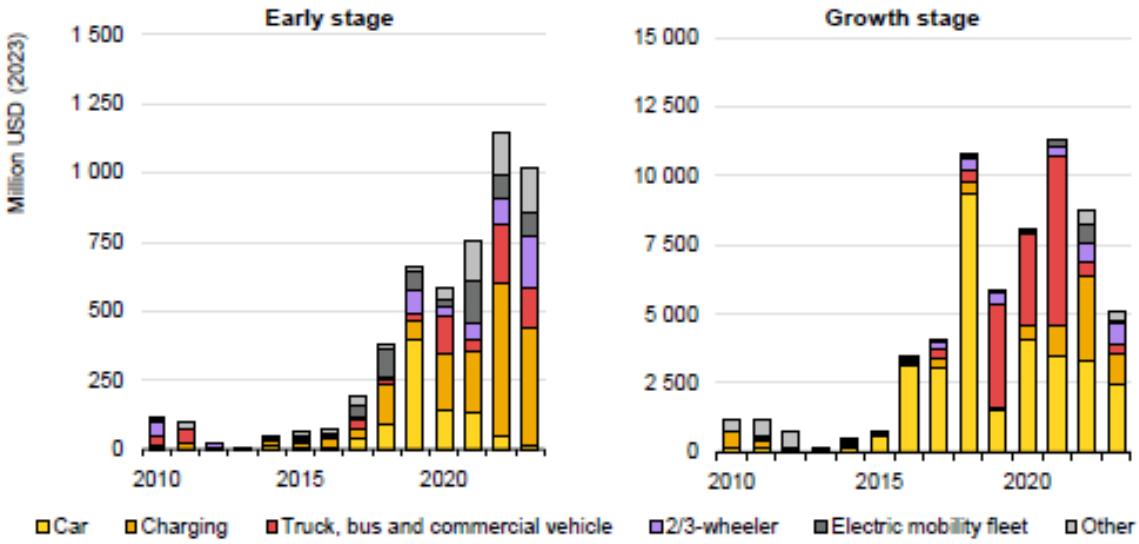
- Chinese electric truck maker **DeepWay** raised USD 110 million in series A funding to start mass production, after having raised USD 70 million in 2022 to fund R&D and early-stage manufacturing.
- In the 2/3W space, Benin-based start-up **Spiro** raised USD 60 million
- Indonesian **Maka Motors** raised over USD 37 million
- **Volta** Indonesia was able to raise USD 35 million
- Brazilian Vammo raised USD 30 million
- Indian **Simple Energy India** raised USD 20 million
- In India, **Evera**, a provider of all-electric cab services and management, raised USD 7 million to expand operations in Delhi
- **Zyngo**, an operator of electric last-mile delivery fleets, raised USD 5 million

5.1.2 Growth Investment

Growth-stage investments (i.e. series B and growth equity) dropped 35% to USD 10.1 billion in 2023 as compared to the previous year.

At this stage, battery technology developers attracted USD 5 billion, and electric carmakers USD 2.5 billion, with significant support from public investors, indicating interest from governments to help new entrants ramp up manufacturing capacity or accelerate expansion and deployment. However, growth-stage investor appetite for electric trucks and EV charging dried up relative to previous years. Notable deals include:

- French battery maker **Verkor**, which raised USD 900 million in growth equity from investors including public-private EIT InnoEnergy and BPI France, and major incumbent carmaker Renault. The company also received a nearly USD 700 million grant from the French Government and another USD 650 million in debt from the European Investment Bank to develop a 16 GWh gigafactory project in Dunkirk.
- To support its global expansion, Swedish battery maker **Northvolt** raised USD 400 million from Ontario's asset manager, USD 1.2 billion and then another USD 150 million in debt from public Canadian investors and private banks, a USD 740 million grant from the German Government, and a USD 5 billion loan from the European Investment Bank and Nordic Investment Bank.
- Chinese lithium-ion battery maker **Hithium** also raised over USD 600 million
- Chinese electric carmakers continued raising money in 2023, such as **Hozon** and **Rox Motor**, which each raised around USD 1 billion. Like other Chinese new entrants, Hozon Automobile is looking to expand in overseas markets as well as domestically, and could go public in Hong Kong. Rox Motor launched its first model in 2023, an electric SUV priced under USD 50 000.
- Premium electric carmaker **Avatr** raised USD 400 million, after having raised a similar amount in series A funding in 2022
- In the electric taxi fleet space, India-based **BluSmart**, a start-up providing ride hailing services, raised two rounds of USD 42 million and USD 24 million in growth equity in 2023, and another USD 25 million in 2024. However, there has been fierce competition with larger taxi fleet apps and operators in the past few years in
- In 2023, for example, electric ride-sharing app Beat, owned by Free Now, withdrew from Latin America.



Source: IEA Global EV Outlook

Several important factors contributed to the downward investment trend in 2023:

- As competition intensifies in EV and battery markets, and as incumbents ramp up their own investments and manufacturing plans, barriers to entry for new actors get higher, and so do investor perceptions of risk.
- The front-running start-ups that raised funds over the 2015–2020 period are now maturing and transitioning to other sources of capital, leaving fewer alternatives for newcomers – early-stage VC for electric carmakers dropped radically in 2023.
- Geopolitical tensions, supply chain disruptions, high energy prices, and rising inflation and interest rates limit the availability of higher-risk capital.
- We also observe a cooldown following the post- Covid-19 boom of 2021–2022, which was fueled by investment restraint during the pandemic and the expectation of significant economic recovery packages afterwards.

5.2 Geographical Concentration of EV Investments

Similar to other clean energy technologies, start-ups for EVs are predominantly headquartered in the United States, Europe or China. There is, however, significant variability across different EV technology areas. Over the 2018–2023 period, in cumulative terms:

- 70% of the VC investments in startups developing electric cars were made in China, 20% in the United States and 10% in Europe
- 95% of the VC investments in electric trucks, buses, and commercial vehicles were made in the United States
- India, the only Emerging Market Developing Economy (EMDE) other than China that has a significant share in global VC markets, accounted for 70% of the investments in start-ups developing electric 2/3Ws. Over the 2018–2023 period, Indian EV start-ups raised USD 2.7 billion, of which over 70% was for electric 2/3Ws. Policy support has contributed to building investor appetite for the EV sector, and the high investment levels seen in 2022 and 2023 will warrant further examination in 2024 and beyond if the FAME subsidies are reduced or phased out. The investment potential in India's EV sector is estimated at

around USD 200 billion, suggesting there are still considerable opportunities ahead for Indian entrepreneurs and start-ups.

- With regards to batteries, start-ups based in the United States attracted most VC investments – from 30% to over 80% of global investments over the 2018-2023 period. Investments in battery makers, however, were split evenly among major VC markets, with 30% each for China, Europe and the United States. It is noticeable that battery VC remains extremely limited in historic battery-producing countries such as Japan and Korea, where technology innovation through startups is generally less common.

5.3 National Financing Landscape

The Pakistani investment landscape is populated by a diverse range of investors, each with their own set of investment mandates, appetites, investing styles and, origination and due diligence processes. Pakistan's financial sector is dominated by commercial banks with their primary focus on debt. They usually invest in mature companies with an established business model, positive cash flows and which can offer high quality collateral. Most commercial banks also have an equity investment desk, but their equity exposures are very limited, again mostly in mature companies. Some banks like HBL and Bank Alfalah have also entered the local venture capital market but only in a handful deals.

5.3.1 The Pakistan VC Market

The Pakistani VC market started to grow in 2016-17 when 3G and 4G technology became available in the country. Since then, over USD 1.0 billion has been deployed in VC funding in the country, as per an article in Dawn by the CEO of an active VC fund in Pakistan.

As per i2i, the VC funding record of Pakistan has been mixed, with 2021 and 2022 standing out with over USD 350 Million funding each, which was a notable achievement for the Pakistani startup landscape. However, with the global downturn in startup financing and Pakistan's local economic turmoil, the funding numbers shrunk in subsequent years:

Year	VC Funding into Pakistan
2019	USD 47
2020	USD 64
2021	USD 354
2022	USD 356
2023	USD 74

As per research by i2i, in year 2023, around USD 74M were raised in Pakistan across 38 deals, out of which 19 deals (USD 35M) were closed by international investors, 7 deals (USD 7.4M) were fed by local investors while the remaining 12 deals (USD 26.8M) had both local and international funding.

The popular sectors in 2023 have been Fintech (USD 19.5M across 7 deals), E-commerce (USD 22.2M across 4 deals) and Logistics (USD 12.2M across 4 deals). Most of the deals have been at the pre-seed and seed stage.

5.3.2 EV Financing

Fund raising for EV companies in Pakistan has its own unique challenges, the top of which is the uncertainty about the velocity of growth of this market which in turn depends on the pace of EV adoption by business and consumers in the country. Although, there is great interest by investors in the local EV space, they are still cautiously watching how the EV space is gradually shaping up. There is definitely more interest in the 2-wheeler segment than other segments owning to the larger market size and scalability scope, and expectation of it growing faster than the remaining segments as is the case of many other developing countries like India.

Notable EV Financing Deals in Pakistan

The most notable deals in the EV sector so far include:

EZ Bike, a 2-wheeler EV company, was the first electric mobility startup company in Pakistan to successfully raise a pre-seed round of USD 1.0 Million. The pre-seed round was raised in 2022, from Pakistan's i2i Ventures, Walled City Co, GroundUp, and leading angels in the United States, including a tech billionaire whose name was not disclosed.

Zyp Technologies, again a 2-wheeler electric vehicles startup, successfully raised a seed funding round of USD 1.2 Million led by Indus Valley Capital followed by a recent pre-Series A round of USD 1.5 Million (SAFEs) by Shorooq Partners UAE and Indus.

5.3.3 Consumer Financing for EVs

The other financing support needed for the EV sector to grow is from the consumer's side where the consumer has financing options available from financial institutions.

Most commercial banks in Pakistan do have consumer financing options for ICE 2-wheelers and 4-wheelers, as well as fleet finance options as a B2B financing solution. Access to financing for purchasing EVs, however, has been limited so far in comparison to traditional vehicles. This financial barrier has restricted the ability of a significant portion of the population, including consumers and small businesses, to transition to EVs. Moreover, the high-interest rate and cost of capital make EVs an unattractive option for prospective buyers.

An example for an EV-specific consumer loan is Allied Bank Limited's special financing product for EV bikes named, Allied Electric Bike Finance with the following features:

- Flexibility to choose repayment period from 1 to 4 years
- Loan amounts up to Rs.400,000/-
- Personal Equity – Minimum 30%

5.3.4 Credit Guarantees and Mark-up Concessions

There are considerations by the Government to introduce a credit guarantee scheme for EVs through SBP and fix the interest rate equal to the Karachi Interbank Offered Rate (KIBOR) for EV purchases, however, there has been no formal progress on this yet.

One thing is certain – the pace of EV growth in Pakistan will depend greatly on how the financing landscape shapes up in future, which in turn will depend on a joint collaborative effort by all stakeholders including investors, policymakers and entrepreneurs.

Section 06

RECOMMENDATIONS FOR EMBRACING CHANGE

Based on the information gathered from various primary and secondary sources, and presented in this report, our discussions with the local EV stakeholders, examples from other global players in the EV market and our own analysis, we are pleased to put forth certain recommendations that may be useful for catalyzing the electric vehicle market development in Pakistan. As the country aims towards a sustainable future, the chapter on "Recommendations" is presented below as a baseline of actionable guidance in the realm of electric vehicle EV adoption.

As Pakistan charts its trajectory towards a cleaner, greener transportation paradigm, the imperative for strategic recommendations becomes increasingly pronounced. This chapter offers a cohesive framework encompassing policy imperatives, infrastructure enhancements, market incentives, and community engagement strategies to galvanize the widespread adoption of EVs. The recommendations in this section are divided into two categories; macro level recommendations for all stake holders including regulators and the government and specific recommendations for AP to assist AP in playing a role in the development of Pakistan's EV landscape.

By embracing following recommendations, stakeholders can seize the opportunity to lead the charge towards a sustainable future, positioning Pakistan at the forefront of the global EV revolution.

6.1 Recommendations for the Regulators and Government

The following section lists down some recommendations for the Pakistani government and the regulators at large to address the policy gaps to help develop the EV landscape In Pakistan.

6.1.1 Regulatory and Administrative Framework

The regulatory framework should provide a detailed and comprehensive plan for EV adoption in Pakistan. The existing framework demonstrates progress in fiscal regimes but lacks specificity in defining EV components for the industry.

The WP-29 regulatory framework (The 1958 Agreements by the UNECE World Forum for Harmonization of Vehicle Regulations) presents an ideal approach to developing a comprehensive framework for Pakistan, addressing the policy gaps, and providing clear guidance for the industry's development. To effectively leverage the membership of the WP-29 framework, a clear time-bound plan must be established to enforce all standards mandated under the framework

Furthermore, the development of a dedicated Electric Vehicle Board, training custom officials on EVs, capacity-building policies for relevant staff, and creating specialized groups within government ministries for coordinated EV policy oversight and implementation are essential.

6.1.2 Technology Standardization and Enforcement

Standardization plays a crucial role in the development of any industry. It ensures low quality products do not enter the market. In Pakistan enforcement of standards is non-existent, allowing poor quality vehicles and parts to be manufactured, or imported.

Prime targets for standardization are the EV batteries and motors, which are the costliest parts of an EV. An effective proposal would be to have a few standard battery models which will be used by all manufacturers – this will solve multiple problems, including enabling mass production volumes, which in turn will ensure lower costs per unit of product and vendor interoperability.

6.1.3 National Center for Electric Vehicles

The establishment of a center envisaged in the 2019 National Electric Vehicles Policy should serve as a startup enabler, providing detailed technical, business, and Human Resource objectives for the industry. The center may be expanded to provide additional services (e.g., consultancy, product testing laboratory) to enable it to be self-sustaining.

6.1.4 Open-Source Technology

By making technology readily available, investment can directly result in local manufacturing, reducing time and potential failure associated with technology development. Encouraging the use of publicly available technology can foster innovation and collaboration in the EV industry. This approach ensures that research funded by taxpayers' money benefits the wider society and facilitates the growth of the EV sector.

6.1.5 Import Limitations

Policies should focus on the development of the local industry, as is the vision manifested by India. A time-limited import strategy, accompanied by increasing tariffs on EVs over time, can incentivize local development. This approach encourages the localization of high-tech parts and components in the EV industry, ensuring long-term sustainability and growth. A notable threat for companies pursuing indigenization of EVs in Pakistan is imports of Completely Built Up (CBUs) units, and CKDs from countries like China; therefore, clear short-term and long-term policies should be in place allowing some protection for the local industry in the beginning and gradually transitioning to a free trade mechanism.

6.1.6 EV Affordability and Government's role

The prime enabler to affordability is economies of scale. The government can play a pivotal role to enable affordability of EVs by enabling consistent and long-term demand. The current policies make business attractive however, these do not directly create markets. A few proposals to ensure large scale volumes are put forward below:

a) **Duties and Tariff Relaxation:** Given the complexity in determining tariffs, an efficient way adopted by India is to have a national tariff policy which states *"the electric vehicle (EV) commission shall not exceed the Average Cost of Supply (ACoS)*[39] *by more than 15%"*. As the price for EVs decline In the future, the offered tax abatement could be decreased. However, the government should also ensure that this limited margin imposition does not discourage EV manufacturing and enough Incentives are still available for EV players that make business and economic sense.

b) **Easy loans for EV purchase:** Government should provide access to easy loans for EV purchase, which could include lower subsidized rates, less stringent collateral and documentation requirements, longer allowed tenures, higher borrowing entitlements, principal repayment moratoriums etc. One option is to expand the scope of State Bank's export-related loans such as FAPC and LTFF to include the EV sector.

c) **Mandatory Phase-out Policy:** This policy aims to remove highly inefficient traditional vehicles that have been in operation for an extended period, such as 40-year-old vehicles, from the roads. By phasing out these vehicles, the market will experience increased demand for newer and more efficient vehicles, reducing the need to sustain a wide variety of parts for outdated models. Implementing this policy effectively would require a well-structured ***disposal strategy*** involving all stakeholders. This strategy should address the environmental impact of vehicle disposal, recycling of usable parts, and responsible disposal of non-recyclable components.

d) **Export Focus:** Price sensitivity is one of the core challenges for the auto industry's growth. However, this is a local challenge. With exports, Pakistan's low-cost talent may be exploited for higher returns and volumes. To enable car exports, Pakistan has a long and arduous journey ahead – international requirements require significant technical infrastructure upgrades. Parts export is however a low hanging fruit that may be exploited relatively easily.

[39] https://e-amrit.niti.gov.in/electricity-cost-for-charging

e) **EV Registration process:** Governments should simplify the EV registration processes and provide support for new industry setups through rent-free land leases, thereby reducing financial barriers and encouraging EV adoption and production.

6.1.7 Battery Technology Research

Given that the battery is the costliest component of an EV, conducting battery research focused on creating a Pakistan-centered product using local materials is crucial. This would contribute to lower costs and easier implementation.

6.1.8 Infrastructure and Charging Network

To incentivize charging infrastructure, the government can offer incentives in the form of tax exemptions to the company developing charging infrastructure. This tax exemption can be removed once a sufficient number of EVs have been incorporated into the transportation network in Pakistan.

6.1.9 Public Awareness and Education

Public awareness and education campaigns must be designed to enhance public understanding and acceptance of EVs. This involves launching nationwide educational campaigns, partnering with educational institutions to include EV technology in curricula, and organizing events to showcase the latest EV technologies. The objective is to foster a positive perception of EVs and increase consumer awareness about their benefits.

6.1.10 Environmental and Recycling Measures

Policies to address the lifecycle management of EV batteries are needed to address environmental concerns related to EVs. These policy interventions aim to develop a regulatory framework for recycling EV batteries, encourage businesses focused on battery second life, and create guidelines for safe disposal or secondary use, ensuring responsible management of EV batteries throughout their lifecycle.

6.1.11 Green Initiatives and Emission Reduction

Zero-Emission Vehicle (ZEV) Mandate, Green Public Transport Initiatives, Residential and Workplace Charging Incentives, Low Emission Zones and Congestion Charges may be designed to promote environmentally friendly transportation. These include mandating a certain percentage of vehicle sales to be zero-emission, electrifying public transport, incentivizing the installation of charging stations in homes and workplaces, and implementing low-emission zones in urban areas.

6.2 Recommendations for AP

The following sections discusses some opportunities and lists some actionable recommendations for AP.

AP must consider that the EV sector in Pakistan is still in its inception phase. Most the EV manufacturers in Pakistan are newly established ventures with limited financial resources and lack of sophisticated production facilities. There are no big corporate players like Honda, Toyota or KIA in the market yet, although all of them are definitely watching the market very closely and are waiting for the right time to enter. It is expected that when these players do decide to enter the market fully, that is when the regulators and policy makers will also seriously frame policies for the

EV sector. Till that time, the stakeholders should be prepared to work with gaps in the policy framework, frequent changes in the existing policy and regulations and difficulties in policy implementation.

The electric two and three-wheeler segment provides many valuable business opportunities to the EV and parts manufacturing sector. This is due to several underlying reasons. First, the two-wheeler segment offers the largest market potential in terms of vehicle numbers. There are around two million registered two-wheelers in the country which are a potential candidate for transition towards EVs. The highest demand for EVs is in the segment for three-wheelers, and the electric three-wheelers offer up to 70% reduction in operating expense in contrast to their ICE-equivalents.

Following opportunities[40] exist in the electric two- and three-wheeler segments in key automotive parts and components industry.

Short-Term Opportunities in the Two and Three-Wheeler Segment:

- The lithium-ion battery pack manufacturers can utilize imported cells to locally assemble battery packs. This approach of locally manufacturing battery packs using imported cells can potentially reduce the price of the battery and ensure prompt repair and aftersales services.
- Through technology partnerships with globally well-established companies in electric motor manufacturing, the local players can save time and resources needed to in-house design and develop motors with required characteristics.
- The current and prospective electric two and three-wheeler manufacturers can leverage the indigenous ICE-based ancillary industry for provisioning of non-EV-specific parts. Such an approach will enable the manufacturers secure a reliable supply chain of automotive parts and reduce the cost of the vehicle.
- While the purchase cost of a new electric two- wheeler in Pakistan is at least USD 800, retrofit kits provide a cost-effective solution for vehicle owners to transition towards EVs. Therefore, the electrification of the two-wheeler segment via retrofit kits can enable manufacturers capture larger market share in the short-term. Electric Owners of electric three-wheelers can also benefit from retrofit kits.
- The battery swapping regime provides an effective alternative to the conventional three-wheelers with fixed batteries carrying a much higher upfront purchase price. Therefore, in the short-term of next five years, local manufacturers can introduce vehicles customized for battery swapping protocols.

It is important for AP to recognize that its intended financing capacity of USD 100-200k per business venture will not be adequate for most of the existing EV players in the Pakistani market to fully meet their financing needs. Moreover, AP is considering debt financing, which is generally not attractive for a start-up stage company, in a market that is still in the inception stage.

However, AP's financing can be very useful for EV players who, despite exhibiting a promising business model, fall into the following categories:

[40] Indigenization of EV value chain in Pakistan for two and three wheelers, 2024- LUMS

- Currently do not have access to equity financing,
- Have their runways from existing funds ending soon
- Cannot afford debt at high market price
- Need bridge financing for them to sustain till they reach their next equity financing round.

Therefore, AP's funds should be utilized for all activities that could help an EV company to improve its chances of raising more investment. This could include:

- Utilization of funds for product development/ improvement
- Technical or other capacity building
- Licensing and certifications
- Marketing and sales support to improve traction
- Providing subsidy or incentives to buyers or suppliers
- Production facility enhancement
- Important inventory buildup

AP could also develop partnerships with other financial institutions, regulatory bodies, international organizations, trade unions of auto and auto parts sectors etc. to work jointly in different areas which would help in improving the financing landscape for EV players in the country. It Is Important that AP considers the following criteria for selection of companies which they intend to finance.

There must be a robust business model to succeed in a future competitive industry and capitalize on the growing demand for sustainable transportation solutions. Here are key components that constitute a proper business model for an EV company:

- **Management Team and Industry Expertise**: AP must evaluate the company's management team's experience and industry expertise. A capable management team especially committed founders enhances the company's ability to execute its business plan and navigate industry challenges. AK needs to assess the founders and managers for skills, expertise, experience etc.

- **Product Strategy:** There must be a clearly defined target market and their product, marketing and other strategies must be aligned with it. They could also plan to target multiple consumer segments in both B2B and B2C markets but they should be able to research and understand each of these segments well, and have proper strategies and plans for all of them.

- **Focus on Quality, Reliability & Safety:** Companies must have a major focus on quality of product, both from the technical and reliability perspective which means they are either importing components from a reputed supplier or are capable of manufacturing/ assembling them in a quality-focused environment with skilled manpower and proper quality checks in place. Due to limited funds and managerial myopia, founders may exhibit a tendency to save costs and target short term sales and profitability, compromising on quality which will eventually result in failure with more choices and brands coming up and regulations getting stricter.

Jolta is a major example in this context – they compromised on their product quality and reliability, and after-sale services which created a bad word for them in the market. AP must carefully assess the quality of the final product and components especially battery, motor, BMS & motor controller software, electronics and chassis. – For this, technical help could always be sought from expert third parties. Safety of riders also needs to be of prime importance as any equipment malfunction such as battery fire could expose any company to a huge reputational risk.

- **Production Line:** The company must have a reasonable sized production facility in place, meeting present and expected future regulatory requirements, and also should have a suitable Installed capacity to meet at least its 2-year production targets.

- **Technological & Product Differentiation**: Companies that focus on developing or partnering with cutting-edge technology for batteries, motors, electric drivetrains, and charging infrastructure to offer superior performance, range, and efficiency compared to competitors will always have an edge. For Instance, Zyp technologies has focused on its under 2-minute battery swap due to its special self-developed battery connector which could be an attractive proposition for consumers going for battery swap charging model with frequent battery removal and installations in 2W EVs.

Similarly, any value additions in the product, both free and for a price, such as slight design and aesthetical modifications for women, option of customized containers for couriers, special paint or sticker options, etc. are always welcome offerings for consumers and can provide a competitive advantage.

- **Charging Infrastructure:** Offering innovative charging solutions such as the battery swapping models where the consumer does not have to purchase the battery with an EV purchase may be an attractive option; however, availability of a swap station in close proximity for convenience of the consumer becomes important in this case.

- **Distribution and Sales Channels:** A proper distribution strategy—direct sales, online platforms, dealerships, or a combination thereof is very important. Consider the customer experience and after-sales service as crucial elements.

- **Business Partnerships:** Collaborations with other companies in the EV ecosystem, such as battery manufacturers, technology providers, or energy companies, to enhance product offerings and operational efficiency are positive traits to look for in a prospective borrower.

- **Brand and Marketing Strategy**: They should have a plan to build a strong brand identity emphasizing sustainability, innovation, and reliability.

- **Long-term Sustainability**: Company should be able to plan for long-term growth and sustainability by investing in research and development, maintaining a strong balance sheet, and anticipating market trends and consumer preferences.

- **Diverse Revenue Streams**: A diverse range of revenue sources may always be better than one revenue stream. Look for companies that think beyond vehicle sales, such as charging fees, subscription services (e.g., software updates, maintenance), leasing options, spare parts sales, maintenance etc.

- **Level of Indigenization/ Localization**: If the quality standards are being met, it may be useful for companies to use as much local components for production as possible. In-house or local outsourced procurement Is usually always cheaper, can be modified relatively easier as the design evolves, and avoids supply bottlenecks in case of Imports curtailment or exchange rate dynamics. However, the battery cells, motors, most electronics and in most cases, the software component such as BMS, motor controller, IoT etc. need to be imported.

  Also, it may be advisable for companies not to manufacture all components themselves. For Instance, it might be feasible for a 2W or 3W producer to procure battery packs, battery charging equipment or software from other companies with more expertise and economies of scale

- **Financial Parameters:**
  - Product pricing should be appropriate, matching with target market affordability but at the same ensuring adequate margins. Remember, as competition Increases, it may not be possible to Increase prices later.
  - The gross margin needs to be in check and at least at a level that could generate profits in future when volumes go up. Since It's a newer market and it may take several years for the market to grow to substantial levels, the Company should have a plan to turn EBITDA positive with medium term realistic sales targets Ideally not more than 3 years. There may be cases like for companies with battery swap business models where the companies will retain ownership of batteries and will earn from exclusive charging subscriptions – In that case, the EBITDA positive stage will come much later.
  - The extent of a company's HR expenses (especially founder and management salaries), marketing costs, R&D Investments, rental expense etc. must be justified and aligned with the company objectives, Its remaining runway from existing funds and growth plans. Companies need to be frugal to ensure long term survival and growth.
  - Company's tied up cash in inventories, account receivables or other non-productive assets must also be taken account of. For EV startups In Pakistan, any such assets will seriously impact its survival.

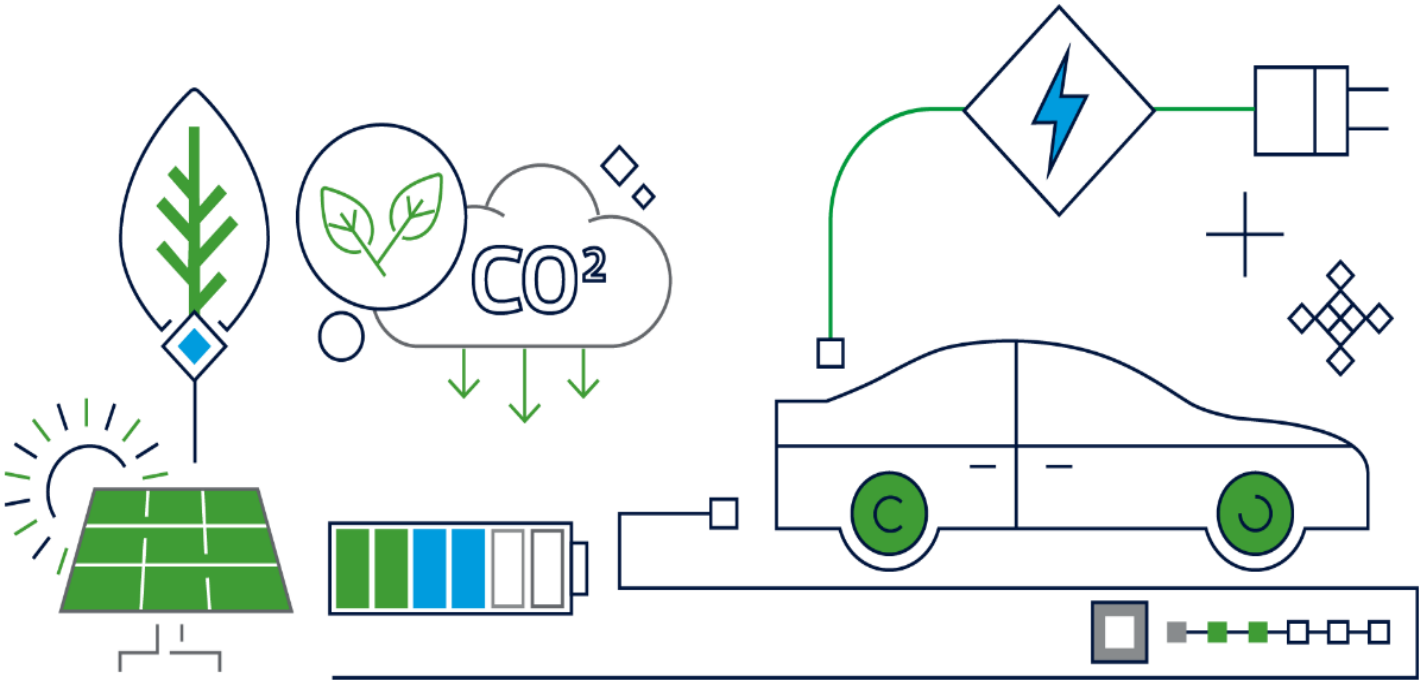
ANNEXURE

Annex 01: Commonly Used Charging Connectors

Annex 02: List of 2-Wheelers, and 3-Wheelers in Pakistan

Annex 03: List of Major Global 2-Wheelers, and 3-Wheelers

Annex 04: Due Diligence Sheet for Selected Companies.



Annex 01: Commonly Used Charging Connectors from IEC 62196

Type 01		Also known as the SAE J1772 connector. Type 1 can be used for Level 1 and Level 2 charging. This connector is most common in North America and Japan.
Type 02		Also known as the "Mennekes" connector. Type 2 can be used for Level 1 and Level 2 charging. This connector is most common in the EU.
GB/T (AC)		A connector designed by and used exclusively in China.
DCFC Couplers (DC Charging)		
CCS 1		Combined Charging System 1 (CCS1): A charging connector that can be used for DCFC only. This connector type is an extension of the SAE J1772 connector (detailed above). This charging standard is most common in North America.
CCS2		Combined Charging System 2 (CCS2): A charging connector that can be used for Level 1, Level 2, or DCFC. This connector type was originally developed in Germany. This charging standard is most common in the EU and India.
CHAdeMO		CHAdeMO: A charging connector that can only be used for DCFC. This connector type was developed by a group of Japanese automakers and occurs primarily in Japanese EVs sold to the United States and Japan
GB/T (DC)		GB/T: A connector designed by and used exclusively in China.
AC Level 2 and DCFC		
Tesla		Tesla: A charging connector that can be used for both DCFC and Level 1 and Level 2. Proprietary to Tesla vehicles. Used in all Tesla markets except China and Europe.

Source: report "Building Blocks of Electric Vehicle Deployment – A Guide for Developing Countries By NREL/ USAID

Annex 2: List of 2-Wheelers and 3-Wheelers

List of 2-Wheelers

S. No.	Company Name	Products	PIce Range	Business Stage	USP (If any)
1	Honda Atlas	BENLY-e	Not yet announced	Launched; commercial sales not yet open	Top existing brand in Pakistan's traditional bikes market with major market share
2	Zyp Technologies			Trial over; commercial production to begin	Focus on quality and technology; an equity funding round raised
3	Vlektra/ Vitality Electric Vehicles	Bolt, 1969, Retro and Velocity	369k-619k	Commercial Production	Aesthetically very attractive, higher social class niche market targeted
4	Mode Mobility	C-Series, P-Series & A-Series	375k	Pre-commercial production	Aesthetically attractive
5	EZ Bike/ Roamer Technologies	Electron & Bolt	130k-225k	Commercial Production	Focus on quality and technology; two equity funding rounds raised
6	AIM Motors	Nayel 3.8E		Pre-commercial production	Aesthetically attractive, Retro braking
7	Metro/ Pak Star Auto	M6, E8S, LY,A7, Thrill, T9, Wonder	129k-330k	Commercial Production	Broad range of electric motrocycles, scooters and bikes; Known brand
8	Jolta	JE-70D, JE-70Li, JES-70Li, JE-100Li	157k-230k	Commercial Production	First mover advantage, most well-known brand in 2W EVs, over 10k bikes sold, motorcycles and scootie
9	PakZon/ Pakzone Electric Motors	PE-70D, PE-70LP, PE-100D, PE100LP, PES Scooty-100D, FAT Mountain, Caspian & Caspian Plus,	81k-265k	Commercial Production	Known brand, good market traction, associated concern of Jolta, broad range of bikes, motorcycles and scooties
10	Road Prince/ Eiffel Industries	E-Go, Zeus, Zeus XR	260k-278	Commercial Production	Electric motorcycle and scootie, known brand
11	Jaguar/ MS Automobile	E-70, E-70 Supreme, E-125,E Heavy bike, Enzo	240k-370k	Commercial Production	Electric motorcycle and scooter, known brand
12	Evee/ Fusion Engineering	C1, C1 Air, C1 Pro, Gen Z, Nisa, Flipper	95k-300k	Commercial Production	Electric scooters, Attractive modern designs, Specialized range for kids and women
13	Ecodost/ Nova Mobility	ED-70		Commercial Production	Known brand especially in 3W market, strong business group association
14	United Auto	Bullet, Revolt, Electric Smart, Electric Classy, Electric Sharp		Commercial Production	Electric motorcycle and scootie, known brand
15	Crown Motor	T10, T20, Pro	170k-220k	Commercial Production	Known 2W brand, Electric scooties
16	Elite Auto	ES EV M1, M2, S1, S2,S3,S4,S5,S6,S7 & cargo versions		Commercial Production	Very large variety of 2W & 3W
17	YJ/ La He Trading	YJ Future Indus, Azadi, Galaxy, Mehran, Cruise	90k-199k	Commercial Production	Variety of Scooties and a 3W
18	Ride Star Auto	RSEV 70,100,125 (Hybrid & Elect)	250k-320k	Commercial Production	Hybrid & Electric motorcycles
19	E-Turbo Motors	Thunderbrid 1500W, 2000W		Commercial Production	One electric motorcycle

20	Plum Qingqui	QM-70		Commercial Production	One electric motorcycle variant; very well-known brand in traditional 3W market
21	New Asia Auto	Ramza G7, A700,A507	195k-265k	Commercial Production	Small range of electrical scooters & 3Ws
22	Super Star/ Memon Motors	SSE-MDW		Commercial Production	
23	Siwa Industries	SWE Electrical Motorcycle, SWE Scootie		No info availaible	One variant electrical motorcycle & scootie
24	Treet Holding	Voltaic TV-70 Electrical Motrocycle		Commercial Production	One variant electrical motorcycle
25	Sutlej/ Dharala Auto	EDA Electric Motorcycle		No info availaible	One variant electrical motorcycle
26	Alhamdali EPC	No info on EVs found		No info availaible	One variant electrical motorcycle
27	Iner Z Automotive	Electric Motorcycle		No info availaible	One variant electrical motorcycle
28	Bullet 1 Motors	No info on EVs found			
29	HH Trading	E-Hawk		No info availaible	One variant electrical motorcycle
30	Rehman Auto	Rohi RIEV-70		No info availaible	One variant electrical motorcycle
31	Road King/ Waleed Trading	RKEV-70		Commercial Production	One Elecric motorcycle variant; known brand
32	Union Star/ Sara Automobile Ind.	US-Elec Motorcycle 1500W, Elec Scootie 2000W		No info availaible	One variant electrical motorcycle & scootie
33	Prime Star Auto	PSEVS Elec Motorcycle, PAEVS Elec Scootie		No info availaible	One variant electrical motorcycle & scootie

List of 3-Wheelers

S. No.	Company Name	Products	Price Range	Business Stage	USP (If any)
1	Sazgaar Engg.	Eve (various variants like minicab and loaders)		Commercial production	Very well-reputed brand especially in 3W market, experts in chassis production (most other 3W brands have outsourced their production to Sazgaar)
2	Ecodost/ Nova Mobility	3W EV with various configurations		Commercial priduction	Stong corporate group backing
3	Neubolt			In trial run	Best R&D in sector, Strong institutional affiliation
4	Yes Electromotive	Muva, Campus Transit	1,200k-4,200k	In trial run	Aesthetically attractive designs, Niche market (campus vehicles and corporate 3W use)
5	Elite Auto	ES EV C003, 3C5, 3P1, 3P2		Commercial Production	Very large variety of 2W & 3W
6	La He Trading	YJ Future Rickshaw	420k	Commercial Production	Variety of Scooties and a 3W
7	New Asia Auto	NER-EV, NECL-EV		Launched; commercial sales not yet open	Small range of electrical scooters & 3Ws
8	Road Prince/ Eiffel Industries	RPEV-Electrical Loader		Launched; commercial sales not yet open	Small range of 2W & 3W, known brand
9	Alhamdali EPC	Elec Loader EV			Small range

Annex 3: Global 2-Wheelers, and 3-Wheelers

Two Wheelers

Company Name	Country
Jiangmen Grand River Group Co. Ltd.	China
Jiangsu Xinri E-Vehicle Co. Ltd.	China
Loncin Motor Co. Ltd.	China
Luoyang Northern Enterprises Group Co. Ltd.	China
Wuyang-Honda Motors (Guangzhou) Co. Ltd.	China
Ola Electric Mobility	India
Okinawa Autotech	India
Hero Electric	India
Ampere Vehicles	India
Ather Energy	India

Three Wheelers

Company Name	Country
Jinpeng Group Co. Ltd.	China
Huaihai Holding Group Co. Ltd.	China
Zong Shen	China
Weichai Lovol Heavy Industry Co., Ltd	China
Mahindra Electric	India
Piaggio Vehicles	India
Euler Motors	India
Atul Auto	India
Lohia Auto	India
Kinetic Green	India

Annex 4: Due Diligence Findings of Selected Companies

Parameters		Mode Mobility	Vlektra	EZBike	Elixs (Planned product)
Business Model		Primary revenue from sale of 2W EV with additional revenue from maintenance services and spare parts sale	Primary revenue from sale of electric motorcycles with additional revenue from accessories/ spares sales, maintenance, subscription fee for technology suite/ IoT, resale of repurchased bikes	Primary revenue from sale of electric motorcycles with additional revenue from retrofitting ICE bikes to EVs for B2B clients involving converting their petrol-run bikes to EVs, earnings from battery swap network and sale of accessories/ spares sales, maintenance	Primary revenue from sale of 2W EV with additional revenue from maintenance services and spare parts sale
Product Range		C-Series (already produced), P-Series (electric scooter under design & early development phase), A-Series (concept phase)	Four models -BOLT, 1969, RETRO and VELOCITY	2 bike variants – Electron & Bolt, and one type of bike retrofitting kit	1 PLANNED variant
Pricing		PKR 375k	PKR 369k (Velocity), PKR 379k (Retro), Bolt (High end PKR 584k), 1969 (high end PKR 619k)	PKR 225k (Electron), PKR 130k (Bolt)	PKR 325k (planned price)
Local vs Imported Sourcing		50% local sourcing			
Technology	Battery	72V, 3kWh Lithium-ion NCM (Local assembling with imported cells)	Lithium-ion	Lithium Iron Phosphate	Lithium-ion
	Motor	3kW Brushless hub-type DC (BLDC)			Brushless DC electric motor
	Chassis & Aesthetics	Attractive locally made chassis	Very attractive locally made chassis	Modern look	Regular look
	Regenerative braking	Yes	No	No	Yes (Planned)
	Software & Telematics	BMS, digital dashboard,	BMS, Digital dashboard, Vlektra app/ IOT,	BMS, Digital dashboard, App/ IOT,	Yes (planned)
	Technical Certifications	None	None	None	None
	Patents	None	None	None	None
Claimed Range per charge		75 km	70-125 km	Electron (75km), Bolt (50km)	130km (Planned)

Max. Speed	75 km/h		Electron (65km/h), Bolt (35km/h)	75km/h (Planned)
Licensing	EDB & PSQCA approvals in place for C-Series	EDB & PSQCA approvals in place for all 4 variants	Assume both EDB & PSQCA approval taken	None
Team	Qualified team – energetic cofounders with local/ international mechanical & automotive engineering	Excellent team – energetic cofounders with local/ international entrepreneurial, financial, engineering qualifications & experience, one partner is UBLs present CEO	Educated & presentable team (technical capabilities not known)	One cofounder is ex SWVL & ex Bookme (position unknown)
Go to Market & Target Customers	Targeting high end 2W market (0.45M annual ICE sales), urban youth and women, starting from Karachi	Targeting high end 2W market (0.45M annual ICE sales), urban youth and women, starting from Karachi		Targeting youth and budget clients
Traction	EDB & PSQCA approvals in place for 1 model, production unit in place, 2 B2B contracts for future sales in place (to be verified), 100 riders feedback in focus groups	Already sold 450 units in 26 cities, Consumer financing contracts with 4 banks, Collaborations with McDonalds, Fedex, DHL, Dominos & Indrive,	Already sold over 300 bikes, B2B clients include Foodpanda (10 bikes with plans to scale to 500), TCS (50 bikes) and Bahria Town	All technology parameters given are what company CEO thinks they will use one they start production but not certain yet. There are sales shown on the Company income statement but not clear how many bikes were made or sold
Financials	Per bike profit estimated at USD 250k (PKR 70k), As per 2024 management accounts, total assets are PKR 58M (PKR 33M FA + PKR 20M CA –mainly inventory & supplier advances & PKR 5M investments), Assets are funded by equity PKR 38M and debt PKR ------ (debt details to be obtained)	As per FY2024 management accounts, PKR 137M gross sales with PKR 11M GP but PKR 71M net loss, Total asset base is PKR 129M (FA PKR 29M, CA PKR 99M – mainly inventory), Assets are funded by PKR 99M equity and a bank loan of PKR 20M	Claimed gross margin from bike sales (25%), Retrofitting (15%), battery swap (cost covered in 17 months). Its 9-MFY2024 accounts show a sale of PKR 8.85M with a net loss of PKR 102M (huge loss – heavy expenses but inventory investment also considered expenses). Previous years sales were 14M and 28M respectively. Mar24 9M BS shows total assets of PKR 61M (mostly invested in inventory) – assets financed by equity of PKR 34M and loan of PKR 20M.	In FY2023 (audited accounts), total sales of PKR 0.57M with a net loss of 0.06M; total asset base was PKR 0.8M out of which PKR 0.7M was held as cash.

External Funding Already Raised	Nil	Nil	USD 1M seed round raised	Nil
Ask & Intended Utilization	Ask size is USD 5.0M (4.0M for capex/ plant expansion/ R&D and 1.0M for working capital)	Ask size from AP is USD 200k (USD 100k for setting up new stores, USD 100K for working capital)	Ask size from AP is USD 200k to ramp up inventory and supply chain	
Strengths	Attractive & simple design, 50% local sourcing, qualified and energetic team, 18% gross profit,	Production unit with 30,000 units per annum capacity (100 per day), strong social media following, excellent design aesthetics, 3yr (30,000km) warranty on/ 2yr (20,000 km) warranty motor, 450 units already sold, 4 variants for broad target market, 16% gross margin, 2 showrooms in Karachi	Smaller & lighter bikes, lower prices, battery swap arrangement in place, B2B relations already in place with TCS and Foodpanda, good margins,	None
Weaknesses & Risks	Still pre-sale, no sales experience, presently a small unit, no proper trial run, one model in production, High upfront costs with no battery swap option, PKR 200k has substantial repayment risk if the Company does not get more funding to meet its targets needed to become cash flow positive	High overhead costs, upfront costs with no battery swap option, no mention of a proper trial run, more imported parts, PKR 200k has substantial repayment risk if the Company does not get more funding to meet its targets needed to become cash flow positive	Lighter bikes, trial run not known, technical expertise not known, limited models, PKR 200k has substantial repayment risk if the Company does not get more funding to meet its targets needed to become cash flow positive	At idea stage, no details of actual stage of production or design, or production provided
Legal Structure				
Future projection of cashflows (ability to repay), ROI, gearing, interest cover and other ratios.	NA	NA	NA	NA
Recommendation	Except the repayment risk in case Company is not able to raise subsequent funding to turn cash flow positive, it may be a good investment prospect based on its satisfactory product and energetic founders	Except the repayment risk in case Company is not able to raise subsequent funding to turn cash flow positive, it may be a good investment prospect based on its satisfactory product, energetic founders, good traction so far	Except the repayment risk in case Company is not able to raise subsequent funding to turn cash flow positive, we are neutral on this investment prospect – the positives being its energetic founders, good traction, previous financing, battery swapping option, retrofitting diversification and brand awareness	A careful consideration is required since the company still seems to be in the idea stage with no product prototype available, no production facility, no licenses and no founder expertise

Disclaimer/Limitations

- All assessments have been made based on the information provided by each company only – we cannot take responsibility of any incorrect or incomplete information or claims.
- No fair technical assessment of the firms can be made unless physical inspections of their products, components including chassis, batteries, motors, electrical/ electronic components, IoT devices, mobile apps etc. are made through qualified third parties and their third-party trial runs are also arranged. For example, battery testing for EVs are only available in a recently-testing facility setup at LUMS Lahore.
- We should realize that the upper funding limit of AP is much lower than these companies' required funding and these companies are mostly still in the loss/ cash flow negative threshold so AP/ HBL need to assess their debt repayment capacities
- All information and documents need to be verified for authenticity before funding
- It must be noted that EV industry is very new for Pakistani market and consumers so we should expect changes in regulations, market demands, consumer tastes, changing competitions etc. as the local EV sector grows
- In our view, the main traits to find in an EV company in Pakistan should be the founders commitment and capabilities, focus on quality and safety, capability to be able to adapt with consumer demand/ interest, lowest possible fixed costs and a lean company structure, high margins and low breakeven point, good aesthetics, both B2B and B2C focus, wide product range for all segments, highest possible indigenization, use of IOT and telematics, high quality battery and motor management systems, ability to carve out and serve niche markets etc.

THE POWER OF BEING UNDERSTOOD
ASSURANCE | TAX | CONSULTING

RSM

RSM Office

RSM Avais Hyder Liaquat Nauman,
Chartered Accountants

18 B/1, 1st Floor, Chohan Plaza,
Sector G-8 (Markaz), Islamabad

T: +92 (51) 2356041-3

E: islamabad@rsmpakistan.pk
www.rsmpakistan.pk