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INDIGENIZATION OF EV VALUE CHAIN IN PAKISTAN FOR TWO-AND-THREE WHEELERS

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INDIGENIZATION OF EV VALUE CHAIN IN PAKISTAN FOR TWO-AND-THREE WHEELERS

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SUMMARY

Pakistan is a developing economy with per capita income of USD 1,568. Almost 37 percent of the population in the country lives below the national poverty line (USD 3.65 /day 2017ppp). There are twenty-six million two-wheelers and one-million registered three-wheelers on roads in the country, collectively constituting 86 percent of the total vehicular fleet in Pakistan. Most of the population thus relies on two-wheelers and three-wheelers for commute.

Pakistan is facing a severe economic crisis with dwindling foreign exchange reserves, notable trade deficit, and rising current account deficit. Import of petroleum accounts for 30 percent of the total national import bill. The road-transportation sector is responsible for about 60% of the total petroleum consumption in the country. The two- and the three-wheeler segments are responsible for almost 37 percent of the total petroleum (gasoline) consumption in the country. Furthermore, 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 percent of the emissions from the road-transportation sector.

The government of Pakistan in 2020 announced the Electric Vehicle Policy to encourage EV adoption in the country, limit rising air-borne pollution, and reduce burden on the national economy through limiting import bill. The policy offers a range of supply- and demand-side incentives to catalyze country-wide EV adoption. However, despite implementation of the policy verticals, the adoption of electric two- and three-wheelers in the country remains negligible. Many reasons are attributed to the very low uptake of EVs. The foremost of these reasons is inability of the indigenous electric two- and three-wheeler industry to satisfy technological and commercial requirements of the indigenous market. Most the EV manufacturers in Pakistan are newly established ventures with limited financial resources and lack of sophisticated development and production facilities. Another key reason for sluggish EV uptake is the high upfront purchase of electric two- and three-wheelers. The upfront price of these vehicles is two-four times the price of their ICE-equivalents. This is due to the excessive reliance of the current EV industry on the import of EV-specific components of the drivetrain. With absence of reasonable financing options, the purchase price of EVs is beyond affordable limits for most of the prospective buyers. Furthermore, the scanty of intra- and inter-city charging facilities instills 'range-anxiety' amongst EV users.

Rising gasoline prices accompanied by global trends in EV adoption are projected to catalyze Pakistan's transition towards electrified transportation. The large potential market size for EVs in the country provides valuable business and commercial opportunities for automotive manufacturers, parts manufacturers, and charging services providers. In the short-term, i.e., over the next five years, the electric two- and three-wheeler manufacturers can leverage the existing automotive parts industry for ICE-based vehicles for the provisioning of non-EV-specific parts. There are many non-EV specific automotive parts used in the ICE-based vehicular segment that can be leveraged for the development of EVs. This approach allows leveraging existing well-established supply chain of parts from the ICE-based vehicular industry for the development of EVs. Opportunities for the manufacturers exist in their ability to address market barriers impeding EV adoption.

The two- and three-wheeler manufacturers can address the barrier of high upfront purchase price of EVs through offering retrofit services. An old ICE-based two-wheeler can be retrofitted with electric drivetrain to convert it into an all-electric vehicle. 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-vehicles. 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.

Utilization of opportunities in the **short-term** by the electric two- and three-wheeler segments will in turn thrive the associated support industry that provides key automotive parts and components. The batteries in electric two- and three-wheelers constitute more than half of the total price of the vehicle. In the short-term, 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 by almost 20 percent and ensure prompt repair and aftersales services. The electric motor industry has the potential to capture a sizeable market share through achieving required capacities to meet the demand of the indigenous EV industry. Through technology partnerships with globally well-established companies in **electric motor manufacturing,** the indigenous industry can save time and resources needed to in-house design and develop motors with required characteristics. The uptake of EVs in the short-term will require establishment of charging infrastructure. While intra-city demand for vehicular charging can be catered at large through home-based charging, there is a need to provide fast charging facilities across motorways and highways to enable inter-city travel. Establishing of fast charging facilities at strategic locations across key motorways and highways in the country can provide valuable commercial opportunities for the charging services providers.

The medium-term refers to the time from next five years up until ten years. During this time, it is anticipated that indigenous industry has sufficiently matured and there is need for higher degree of indigenous research and development to better serve unique local needs and establish secure supply chain of raw materials. **In the medium-term,** electric two-wheeler manufacturers can avail the opportunity to extend the **battery swapping** regime to the two-wheeler segment. The two-wheelers utilized for commercial purposes are suitable candidate for transition battery swapping regime. Furthermore, as the demand for e-mobility gains momentum, the battery pack manufacturers can establish **partnerships under various modes with global battery cell manufacturers.** Through these collaborations, the indigenous battery pack manufacturing sector can gain access to high quality cells. Similar **collaboration can be established with renowned international motor manufacturer** to leverage their design and expertise for development high-efficiency motors that are suited to serve EV applications.

The long-term provides an opportunity to the automotive and parts manufactures to venture into areas that are totally unfamiliar with presently. These areas can include **EV design and software industry.** The EVs require distinct design due to their unique technical and mechanical parameters such as distribution of the center of mass and weight of the vehicle. This requires redesigning the vehicle. Furthermore, the software in an EV act as a brain of the vehicle controlling most of its functions. The software for EVs are more complex than their equivalent ICE-based vehicles. Pakistan has a reasonably established IT industry that can be leveraged for the development of EV software industry.

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ACRONYMS

AC.....Alternating Current

ADP.....Automotive Development Policy

AIDEP.....Automotive Industry Development and Export Policy

BMS.....Battery management system

CAGR.....Compound annual growth rate

DC.....Direct Current

ECC.....Economic Coordination Committee

EDB.....Engineering Development Board

EV.....Electric vehicle

EVP.....Electric Vehicle Policy

FY.....Fiscal year

GHG.....Greenhouse gas

GoP.....Government of Pakistan

GPS.....Global Positioning System

HTV.....Heavy transport vehicle

HR.....Human resource

ICE.....Internal combustion engine

NEVP.....National Electric Vehicle Policy

R&D.....Research and Development

SDO.....Standards Development Organizations

SoH.....State of Health

TCO.....Total cost of ownership

USD.....United States dollar

01 INTRODUCTION

1.1 THE NEED FOR E-MOBILITY IN PAKISTAN

Pakistan is the 5th most populous country in the world having a road-transportation sector that includes almost twenty-six million two-wheelers, one million three-wheelers, four million four-wheelers and quarter of a million buses and trucks each.[13] The road-transportation sector is responsible for about 60% of the total petroleum consumption in the country. In the FY 23 (July to March) Pakistan's petroleum imports stood at USD 13 billion which accounted for 30% of the total national import bill in the respective period. During this time, Pakistan experienced a trade deficit of USD 23.7 billion and a current account deficit of USD 3.3 billion[14]. With dwindling foreign exchange reserves, the dependence on imported petroleum is a substantial burden on the economy of Pakistan.

The internal combustion engine (ICE)-dominated road-transportation sector is responsible for almost 23% of the total greenhouse gas (GHG) emissions in the country[15]. According to the IQAir, Pakistan ranks third globally amongst the countries with highest concentration of air-borne pollutants[16]. In 2021, Lahore, the second most populous city in Pakistan, was ranked as the most polluted metropolis in the world where 83% of airborne emissions stemmed from the road-transportation sector.

The Government of Pakistan (GoP) announced the Electric Vehicle Policy (EVP) in 2020 to encourage adoption of electric means of transportation and thus limit rising vehicular air-borne pollution, reduce the petroleum import bill, and develop an indigenous industry to serve local needs and offer potential for exports. The EVP offers a range of supply- and demand-side incentives to encourage a paradigm shift in the road-transportation sector. However, since the approval of the policy, the adoption of electric vehicles (EVs) in Pakistan has remained negligible.

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13 (2023) Transport and Communications. rep. Ministry of Finance, Government of Pakistan. Available at: https://www.finance.gov.pk/survey/chapters_23/13_Transport.pdf (Accessed: 01 September 2023).

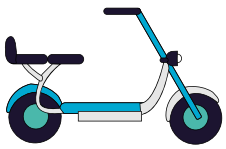
14 Highlights Pakistan Economic Survey. rep. Finance Division, Government of Pakistan. Available at: https://www.finance.gov.pk/survey/chapters_23/Highlights.pdf (Accessed: 02 October 2023).

15 Mir, K.A., Purohit, P. and Mehmood, S., 2017. Sectoral assessment of greenhouse gas emissions in Pakistan. Environmental Science and pollution research, 24, pp.27345-27355.

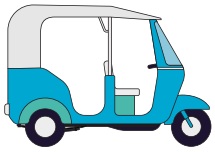
16 Air quality in Pakistan, World's most polluted countries & regions. Available at: https://www.iqair.com/world-most-polluted-countries (Accessed: 31 August 2023).

1.2 THE SIGNIFICANCE OF TWO- AND THREE-WHEELERS IN PAKISTAN

The two-wheelers and the three-wheelers account for 83% and 3% of the total registered vehicles in Pakistan respectively. While the number of registered three-wheelers in the country is close to one million, many believe that the total number of three-wheeled vehicles in Pakistan is almost two million since some prevalent types of three-wheelers, like the commonly known loaders and Qingqi, are ineligible for registration. It is estimated that the registered two- and three-wheeler segments are responsible for 35% and 6% of the total emissions respectively from the road-transportation sector.

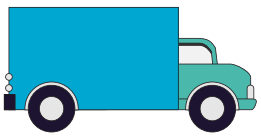


26 Million
2-Wheelers



1 Million
3-Wheelers

4 Million
4-Wheelers



0.25 Million
Buses/Trucks each

While the three-wheelers constitute about 3% of the overall vehicular fleet, their contribution towards release of GHG emissions is 6%. This is because most of these vehicles are utilized for commercial purposes and thus on average traverse more distance daily. Furthermore, it is estimated that the two- and three-wheelers in Pakistan account for 32% and 5% of the gasoline consumption from the transportation segment respectively.

The inflation rate in Pakistan was recorded at 29.2% during the FY 22-23[13]. During this year the Pakistani rupee depreciated by almost 40% in contrast to the United States dollar (USD). The devaluation of rupee accompanied by global trends in gasoline prices resulted in increase in the price of gasoline (petrol) by almost 45% in the respective FY. The two- and three-wheeler users typically belong to the low-income segment of the population that has been disproportionately impacted by the increase in gasoline prices. Many two-wheeler users have responded to the increase in gasoline prices by opting other more affordable means of commute such as mass transit systems. However, such public transport systems in Pakistan offer a very limited spatial coverage. Similarly, the increase in ride fare by the three-wheeler drivers to compensate the increase in gasoline prices has resulted in passengers opting for other modes of transportation. This has resulted in decrease in disposable income of almost a million three-wheeler drivers/owners.

13 (2023) Highlights - Pakistan Economic Survey. rep. Finance Division - Government of Pakistan, pp. 16–16. Available at: https://www.finance.gov.pk/survey/chapters_23/Highlights.pdf.

1.3 PROJECTED EV ADOPTION IN PAKISTAN

The annex 1A lists the year-wise data from the Pakistan Economic Survey 2022-23 of the total (cumulative) number of registered two- and three-wheelers in the country (column B and E)[13]. Based upon this data, we have calculated the year-wise (non-cumulative) vehicle registration count which corresponds to the annual sale of automobiles in the respective vehicular segments (column C and F). From the annual vehicle sales numbers, year-by-year percentage increase/decrease in annual vehicle sales compared to the preceding year has been computed (column D and G). These computations illustrate that the two- and the three-wheeler segments have witnessed an averaged increase in annual vehicle sales by 5.2% and 1% respectively during the described timeframe[14].

In order to project electric two-wheeler adoption in Pakistan by 2030 and 2040, we have assumed that new annual sales in the two-wheeler segment (EVs and ICE-based vehicles combined) will observe a 5.2% year-by-year increase. Annex 1B shows the projected new annual sales in the two-wheeler segment up till 2040 (column B). Using these projected new annual sales numbers, we have computed total registered two-wheelers in Pakistan up until 2040 (column C). The GoP's mandatory EV sales targets, as mentioned in table 1, require the share of electric two-wheelers to reach 50% and 90% in new annual sales by 2030 and 2040 respectively. Based upon the current share of electric two-wheelers in new annual sales in the respective vehicular segment, we assume that the share of EVs increases linearly reaching 50% of annual sales by 2030 and 90% by 2040 (column D). Keeping in view the assumed percentage share of electric two-wheelers in annual sales in the respective vehicular segment, we have calculated the number of electric two-wheelers sold/registered annually in Pakistan (column E) and the total number of electric two-wheelers in the country (column F). The same approach has been used to project electric three-wheeler adoption in Pakistan. Annex 1C shows the projected electric three-wheeler adoption in the country through 2040. The key results of these projections are presented in figure 1 and 2 for the two- and three-wheeler segments respectively.

13 Government of Pakistan (2023) Pakistan Economic Survey. Ministry of Finance. Available at: https://www.finance.gov.pk/survey/chapters_23/Economic_Survey_2022_23.pdf (Accessed: 28 February 2024).

14 It is important to note that we have not included the annual sales numbers (and annual percentage change in sales numbers) for the year 2020 while calculating the averaged increase in annual vehicle sales in the temporal window. This is because during this year the automotive sector experienced severe market disruption due to the impact of the Covid-19.

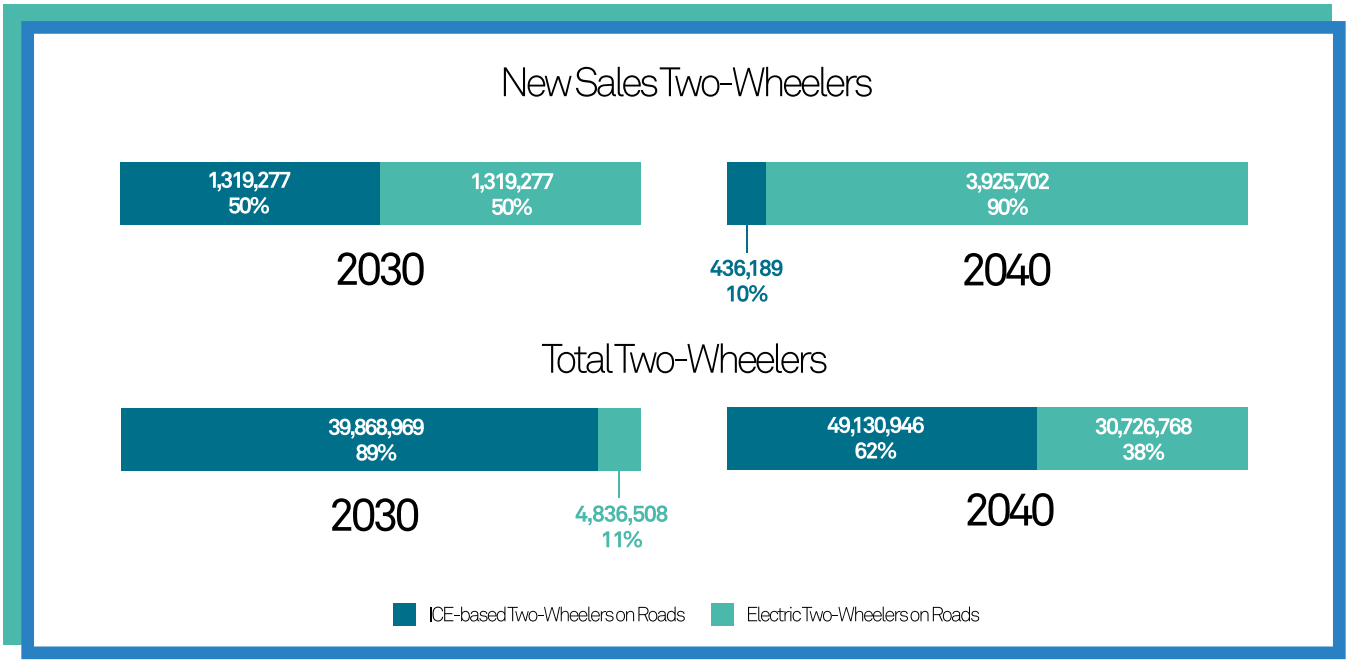


Figure 1: The projected new annual two-wheeler sales and total number of registered two-wheelers on roads.

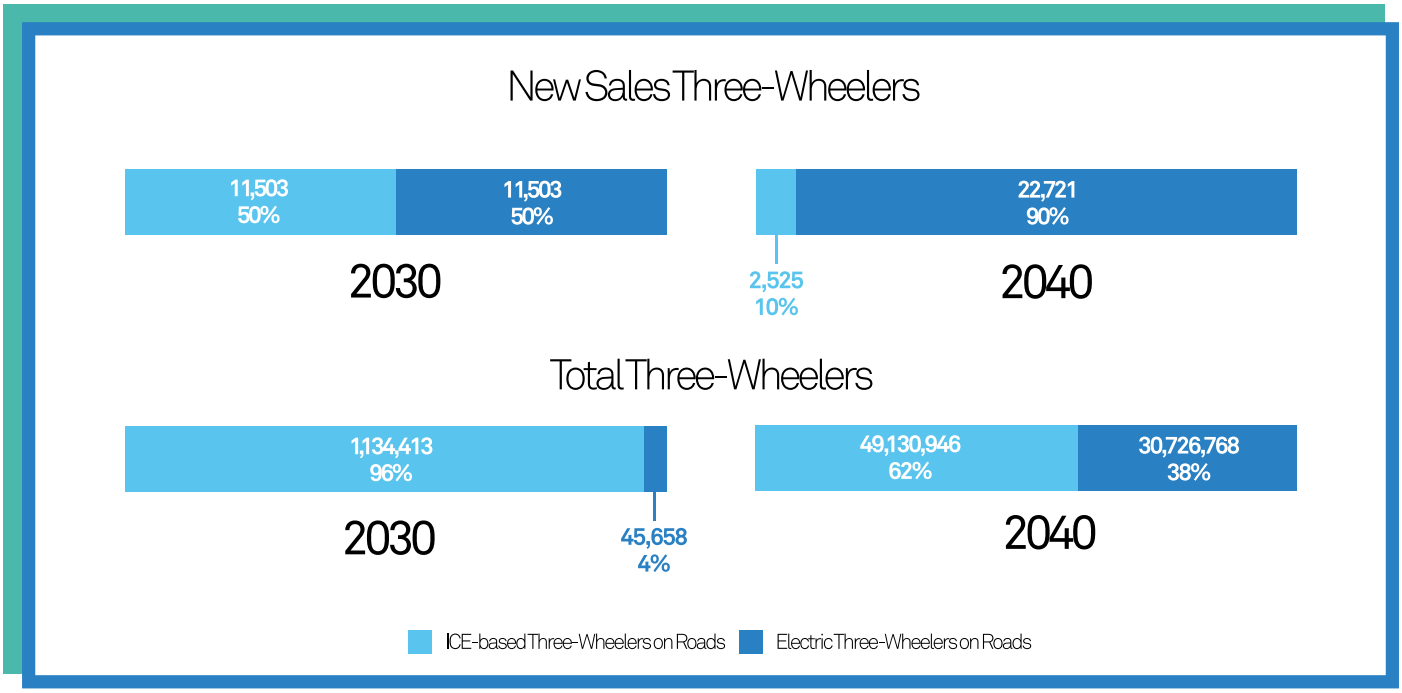


Figure 2: The projected new annual three-wheeler sales and total number of registered three-wheelers on roads.

1.4 GREENHOUSE GAS MITIGATION POTENTIAL AND MACROECONOMIC IMPACT DUE TO PROJECTED EV ADOPTION

The adoption of electric two- and three-wheelers in Pakistan is expected influence the country's macroeconomic outlook. Large-scale uptake of EVs is anticipated to result in decrease in petroleum import bill which in turn will help mitigate the trade deficit of the cash-strapped economy of Pakistan. This section attempts to quantify the reduction in petroleum import bill and GHG emissions through achievement of the GoP's EV adoption targets.

The fuel demand is determined by averaging the annual distances traveled by two- and three-wheelers in Pakistan. This involves dividing the total yearly distance traveled by each vehicle category by its fuel consumption to derive the fuel consumption per vehicle annually. This value is then multiplied by the number of vehicles in each category to ascertain the total fuel usage for the year, measured in barrels.

With the international price of one barrel of crude oil set at USD 78.52, this calculation provides the fuel consumption in USD for each vehicle category annually. When transitioning to electric vehicles, if approved policy targeted percentage of vehicles are converted each year, the fuel requirement for those vehicles is subtracted from the overall segment, resulting in a reduction in total fuel demand for that year. The figure 1 and annex E show the fuel requirement with scenario-A and scenario-B.

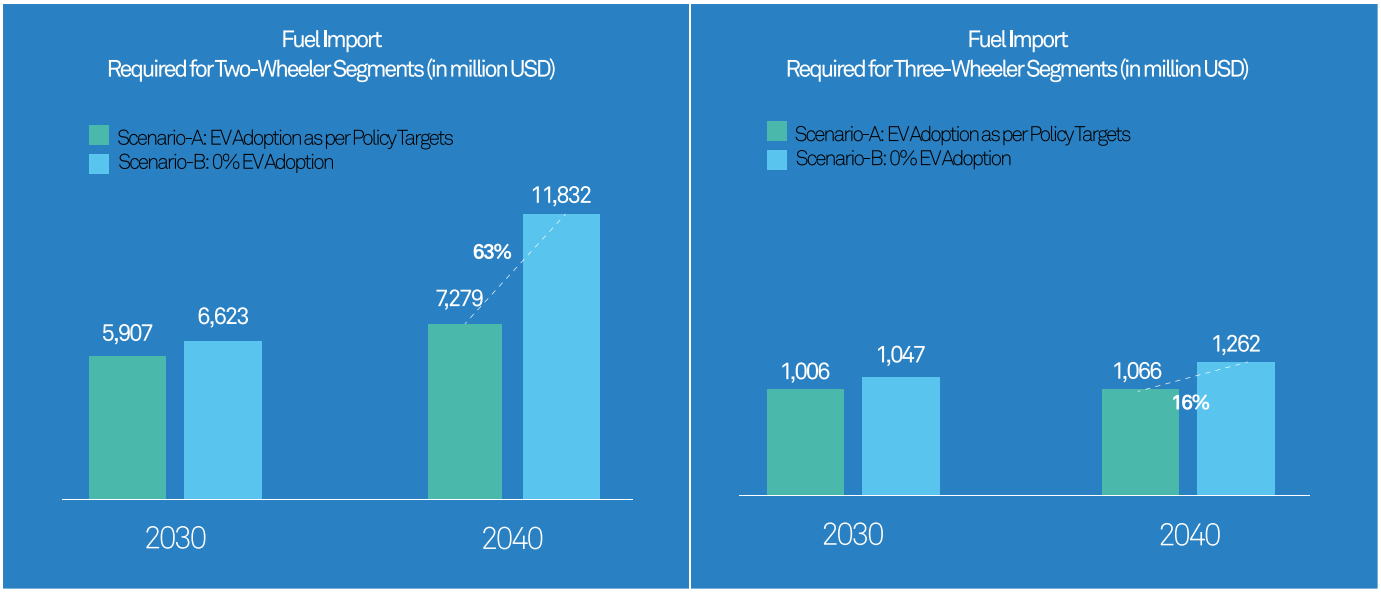


Figure 3: The projected reduction in fuel import bill due to EV adoption as per GoP Targets.

LUMS has carried out extensive onfield surveys of the market to understand the various parameters involved in the operations of two- & three-wheelers. The assumptions for this CO_2 estimation and fuel requirement include:

- The average daily operational distance of two-wheelers and three-wheelers is 40 km and 144 km respectively.
- Average operational days for two-wheelers are 300 and three-wheelers are 312 in a year.
- Fuel consumption of two-wheelers and three-wheelers is around 40 km/liter and 25 km/liter respectively.

Calculation of Emission Reduction:

The emissions are calculated from UNFCCC-approved small-scale CDM methodology "AMS-iii. C: Emission reduction by electric and hybrid vehicles." In the calculations for GHG mitigation potential, default values for different types of fuels as provided by the IPCC have been used as Pakistan country-specific figures are not available. However, the power sector emission factor has been taken from the Indicative Generation Capacity Expansion Plan developed by the National Transmission & Despatch Company of Pakistan. The methodology for estimating CO_2 emissions avoidance involves the following process:

1. Baseline Emissions: Determine average CO_2 emissions from operations or exhaust of ICE two-& three-wheelers over a specified period, including fuel consumption, and maintenance.
2. E3W Emissions: Estimate emissions from the operation of electric two-& three-wheelers, which should be substantially lower, especially when considering that charging is powered by solar energy.
3. Usage Patterns: Calculate the average distance traveled by both ICE-based two- & three-wheelers and electric two-&three-wheelers annually in major cities of Pakistan to understand the total potential for emissions reduction.
4. Energy Source: Factor in the emissions from electricity generation in Pakistan for any supplemental charging needs beyond solar power, using the national grid's average emissions intensity.
5. Emission Factors: Use standard CO_2 emission factors for gasoline and electricity to calculate the emission factor (gCO_2/km) as well as total annual emissions for ICE-based two&three-wheelers and electric two&three wheelers (tCO2/year) respectively.
6. CO_2 Reduction: The difference in total CO_2 emissions between the two scenarios gives the CO_2 avoidance, which is then extrapolated based on the number of electric vehicles forecasted.

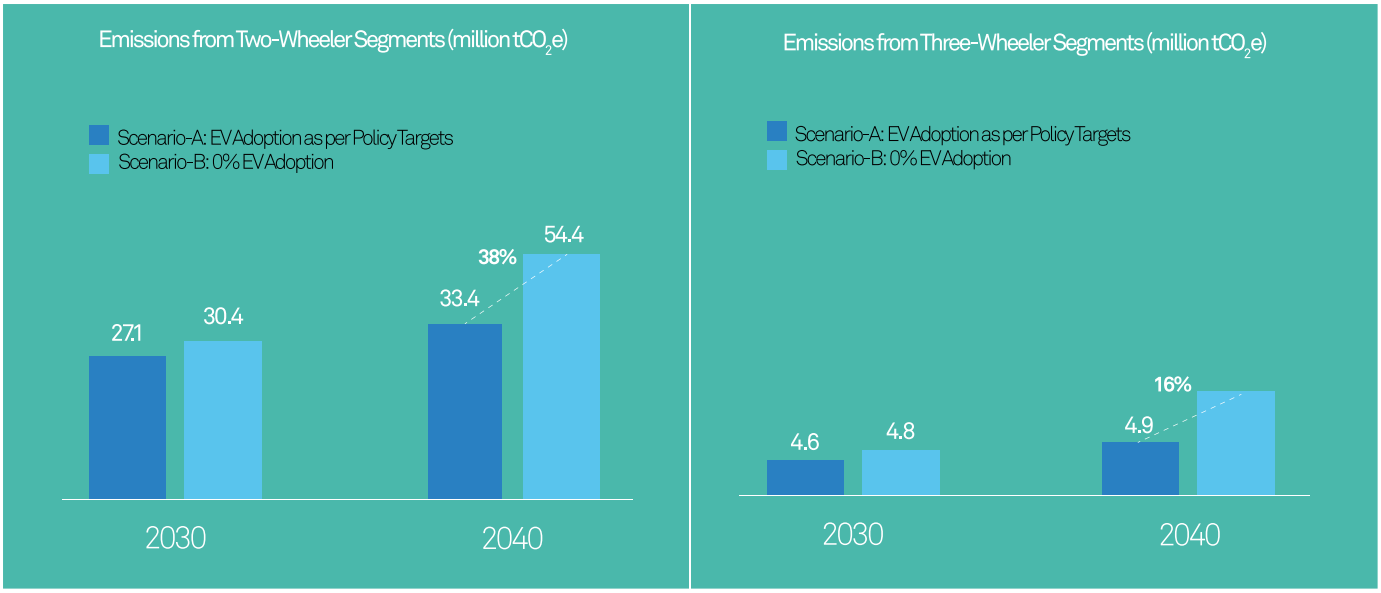


Figure 4: The projected reduction in fuel import bill due to EV adoption as per GoP Targets.

This methodology estimates the broad future impacts of electric two-& three-wheelers by comparing the emissions from traditional ICE two & three-wheelers to the much-reduced emissions expected from the electric vehicles and the solar-powered infrastructure supporting them.

The figure 4 and annex E show the estimated emission saved from the two & three-wheeler segment if EV adoption is as per the government policy target.

1.5 OVERVIEW OF THE ELECTRIC VEHICLE POLICY IN PAKISTAN

1.5.1 EV ADOPTION TARGETS OF THE GOVERNMENT OF PAKISTAN

The GoP initiated its efforts towards reducing vehicular air-borne pollution through revealing countrywide EV sales targets. The Prime Minister's Committee on Climate Change, during its meeting on May 17, 2019, approved the mandatory countrywide EV sales targets as a percentage of overall annual new vehicle sales (by vehicle category) in the country. Table 1 shows these targets, along with their stipulated timeframes.

TABLE 1: EV SALES TARGETS OF THE GOP

VEHICLE CATEGORY	MEDIUM-TERM (5-YEAR) EV SALES TARGET (CUMULATIVE SALES)	LONG-TERM (TO 2030) EV SALES TARGETS (PERCENTAGE OF ANNUAL NEW VEHICLE SALES)	ULTIMATE EV SALES TARGETS (PERCENTAGE OF ANNUAL NEW VEHICLE SALES)
Cars (including jeeps, vans, and small trucks)	100,000	30%	90%
Two and three-wheelers (including four-wheelers of the UNECE 'L' category)	500,000	50%	90%
Buses	1,000	50%	90%
Trucks	1,000	50%	90%

The Prime Minister's Committee on Climate Change further directed the Ministry of Climate Change and Environmental Coordination to develop a policy framework to achieve these targets.

1.5.2 THE NATIONAL ELECTRIC VEHICLE POLICY, THE ELECTRIC VEHICLE POLICY, AND THE AUTOMOTIVE INDUSTRY DEVELOPMENT AND EXPORT POLICY

National Electric Vehicle Policy:

The Ministry of Climate Change and Environmental Coordination developed the National Electric Vehicle Policy (NEVP)[13] as country's first policy framework for developing an EV ecosystem in the country. The NEVP provided a range of supply- and demand-side incentives and directives to help expedite the adoption of EVs across all vehicle segments/categories and overcome barriers in transitioning towards e-vehicles. As the first policy draft, NEVP received diverse response from the relevant local industry and other stakeholders.

13 https://mocc.gov.pk/SiteImage/Policy/EV%20Policy%20Final.pdf

Electric Vehicle Policy 2020-2025:

To address the concerns in the policy draft and overcome shortcomings as highlighted by the stakeholders, the Cabinet Division of the GoP directed the Ministry of Industries and Production to address gaps in the current policy. In consultation with the concerned public and private sector stakeholders, the ministry introduced the Electric Vehicle Policy (EVP) 2020-2025. The EVP 2020-2025 provided an incentive and regulatory package for the electric two-wheelers, three-wheelers, and heavy transport vehicles (HTVs)[13] , which was subsequently approved by the Economic Coordination Committee (ECC) of the federal cabinet in June 2020. The package for electric four-wheelers under the respective policy framework was approved in December 2020[14].

13 http://engineeringpakistan.com/wp-content/uploads/2021/01/EV-POLICY-APPROVED-RECOMMENDATIONS-converted.pdf

14 http://engineeringpakistan.com/wp-content/uploads/2021/01/approvedrec-4-wheelers-converted.pdf

Automotive Industry Development and Export Policy 2021-2026:

The conventional ICE-based automotive industry has been governed by the Automotive Development Policy (ADP) 2016-21. At the expiration of the ADP, the Automotive Industry Development and Export Policy (AIDEP), 2021-2026 was approved by the GoP in June 2021. The AIDEP has a much broad scope, covering vehicles of almost all powertrains including EVs, hybrid EVs, plug-in hybrid EVs and ICE-based vehicles. Many, but not all, incentives for the e-mobility sector from the EVP have been carried forward into the AIDEP 21-26. While there is still confusion amongst the automotive community about the status of the previous two policy drafts, many believe that AIDEP is final policy framework.

1.5.3 INCENTIVES FOR THE ELECTRIC TWO AND THREE-WHEELERS IN AIDEP 21-26

The direct incentives for the electric two and three-wheeler segments, as offered by the AIDEP 21-26, are presented in table 2, while indirect incentives for the respective vehicular segments are appended in annex 1E.

TABLE 2: DIRECT INCENTIVES FOR THE ELECTRIC TWO & THREE-WHEELER SEGMENTS OFFERED BY THE AIDEP 21-26

INCENTIVE TYPE	TWO AND THREE-WHEELER EVS
Custom duty on import of EV-specific parts	1%
Custom duty on import of CBUs	10 CBU units (for each variant) to be allowed at 50% of prevailing custom duty to the extent of a maximum 200 units per company
Sales tax on CBU import	Waived-off
Sales tax on locally manufactured vehicles	1%

Since the approval of the AIDEP 21-26, very few further incentives/regulations have been introduced by the GoP for the EV sector in the country. While there is a policy and regulatory framework in Pakistan governing the e-mobility sector, almost negligible on-road presence of EVs has been witnessed since then. Many attribute this low EV adoption with gaps and shortcomings the policy i.e., AIDEP 21-26. Therefore, it is crucial to first identify these gaps and shortcomings, explore challenges in the implementation, and finally enact effective policy recommendations that address barriers for EV uptake in the country. The subsequent sections of this report will explore gaps and inconsistencies in the current policy framework that have been identified during our interaction with EV industrial stakeholders for the purpose of this study.

1.6 ELECTRIC VS INTERNAL COMBUSTION ENGINE DRIVETRAIN

The EVs and their ICE-equivalents differ significantly in terms of drivetrain and components due to their distinct propulsion systems. In contrast to the ICE-based vehicles, EVs offer relatively silent operation, efficient energy usage, lower operating expense, and thus reduced total cost of ownership (TCO).

Distinct EV Drivetrain and Components:

The EV drivetrain is composed of the following, but not limited to, key components, each playing a vital role in the vehicle's operation:

• Battery Pack:

A battery pack stores electric energy which is then converted to mechanical energy by the motor to propel the vehicle. It consists of individual lithium-ion battery cells arranged in modules or packs. A battery management system (BMS) is also integrated with battery cells/pack, which ensures optimal performance, safety, and longevity by monitoring and controlling each cell/pack.

• Electric Motor:

The primary propulsion source in an EV is the electric motor which converts electrical energy from the battery into mechanical energy to drive the vehicle. Various types of electric motors, including AC induction motors and permanent magnet motors, are used for e-mobility purposes depending on the vehicle's design and performance requirements. In Pakistan, currently, the permanent magnet DC motors, ranging from 1kW-1.5KW, are being used for electric two-wheelers, while AC induction motors, ranging from 3kW-5kW, are being used for electric three-wheelers.

• Power Electronics:

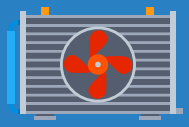
The power electronics system is crucial for managing the flow of electrical energy through DC-AC inverters and DC-DC converters. The DC-AC inverter converts the DC power stored in the battery into AC which is required to drive the induction motor. The invertor also controls the frequency, voltage, and amplitude of AC output to regulate the speed and torque of the motor. The DC-DC converter regulates the high-level voltage of the battery to a lower level such as 12 Volt or 6 Volt for auxiliary functions e.g., lighting, instrumentation, etc.

• Charging System:

Charging an EV is facilitated by the onboard charging system, which converts AC power from external source, such as charging station or home outlet, into DC power to recharge the battery. Some EVs may also feature fast charging capability at compatible charging stations, but this feature is not commonly available in most electric two-and three-wheeler variants in Pakistan.

Battery Pack

Electric Motor



Power Electronics

Charging System

Thermal Management System

Software

Braking System/ Regenerative Braking

• Thermal Management System:

To maintain optimal operating conditions, EVs are equipped with a thermal management system. This system controls the temperature of the battery pack, electric motor, and power electronics through active and/or passive cooling systems.

• Software:

The distinct software in EVs performs several crucial roles that fundamentally include monitoring and optimization of charging/ discharging, state of health (SoH) estimation, and management of energy flow to optimize efficiency. It also oversees energy distribution amongst the battery, motor, and auxiliary systems, and maintains optimal thermal conditions. The software governs the onboard charging system, including charging rates, and protocols, and ensures compatibility and safety. Moreover, it facilitates driver assistance and infotainment features like navigation, and system

• Braking System/Regenerative Braking:

Hydraulic or mechanical brakes are commonly used for e-mobility applications. Additionally, EVs often incorporate regenerative braking systems that capture kinetic energy during braking process and convert it into electrical energy for reuse in the battery.

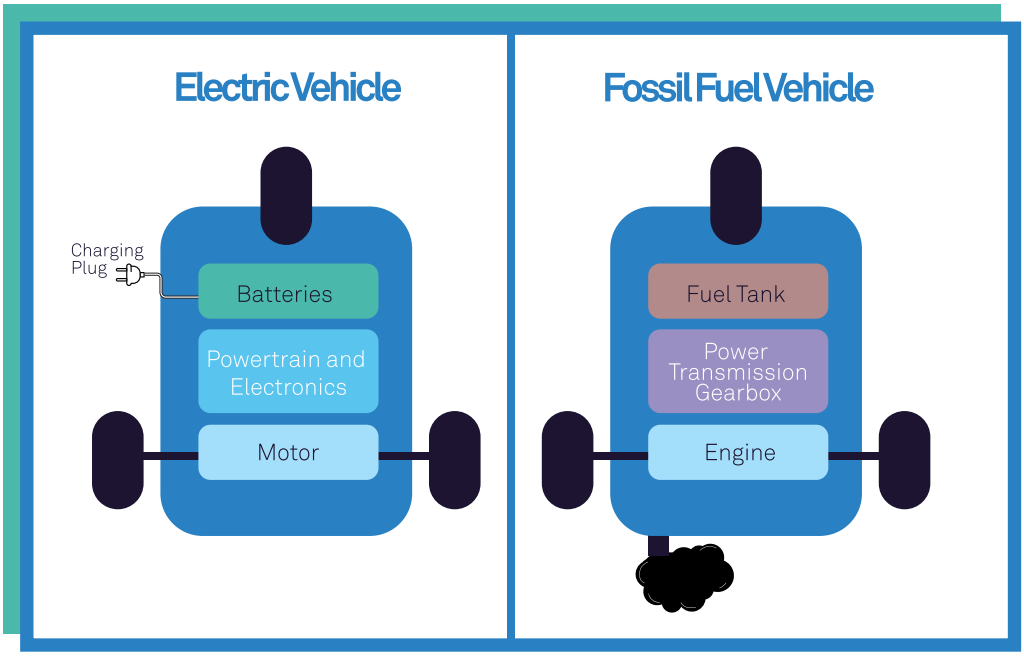


Figure 5: Schematic illustration of the distinct electric vs. ICE-based drivetrain.

Distinct ICE-based Drivetrain and Components:

The ICE-based drivetrain typically consists, but not limited to, of the following key components:

• Engine

ICE-based vehicles are powered by internal combustion engines fueled by gasoline or diesel. They are responsible for converting chemical energy stored in fossil fuels to mechanical energy that propels the vehicle. The engine consists of numerous components such as cylinders, pistons, crankshafts, and camshafts.

• Fuel System

The vehicles are equipped with a fuel tank/ reservoir that is typically positioned towards the rear or underside of the vehicle. The system comprises elements such as the fuel tank, fuel pump, and fuel injectors.

• Transmission

The transmission system transfers power from the engine to the wheels, allowing the vehicle to move at different speeds. In Pakistan, commonly used ICE-based two- and three-wheelers have traditional manual transmission gear systems.

• Cooling System

This system helps regulate the temperature of the engine to prevent overheating. It typically includes a radiator, coolant reservoir, water pump, and a thermostat.

• Exhaust System

This system includes components such as the exhaust manifold, muffler, exhaust pipe, and tailpipe. It is responsible for managing and expulsion of the exhaust gases produced during the combustion of fuel.

• Electrical System

The electrical system is not directly related to the combustion process, but is crucial for starting the engine, powering accessories, and managing various other vehicle functions.

• Ignition System

The ignition system is responsible for igniting the fuel-air mixture in the cylinders of the engine. It includes components such as spark plugs, ignition coils, distributor, and ignition control

• Braking System

The hydraulic and mechanical brakes are installed to control the vehicle's speed and ensure safe stopping distance.

1.7 GLOBAL ELECTRIC TWO- AND THREE-WHEELER MARKET TRENDS

The global market for electric two- and three-wheelers is witnessing significant developments that are reshaping the industrial landscape. One notable trend is the increasing affordability and efficiency of electric two-wheelers, which is expanding their accessibility to a broader consumer base. This shift is particularly evident in emerging economies, where factors such as urbanization and rising disposable income are fueling demand for electric scooters and bikes.
Furthermore, the technological advancements in battery technology are playing a crucial role in improving the range and performance of EVs. The growing affordability and efficiency of lithium-ion batteries, for instance, are contributing to longer driving ranges and shorter charging times for electric two- and three-wheelers.

In addition to the battery advancements, the integration of smart and connected features is gaining traction in the market. Features such as Global Positioning System (GPS) navigation, smartphone connectivity, and real-time monitoring are enhancing the user experience and improving the safety and convenience of EVs.

In 2021
the electric two- and three-wheeler market in the Asia-Pacific region boasted to a substantial size of
USD 14,012.2 million.

Looking ahead, the market is poised for remarkable expansion, with forecasts indicating a surge to
USD 41,018.2 million by 2030.

This growth trajectory reflects a robust compound annual growth rate (CAGR) of
12.7%
expected between 2022 and 2030.

In the electric two- and three-wheeler market across Asia, several key players dominate the landscape with their innovative offerings and extensive market reach. Yadea, Niu Technologies, and SUNRA, based in China, stand out as major contributors to the region's electric mobility sector, providing a wide range of EVs and a strong global presence. Meanwhile, in India, Hero Electric, Bajaj Auto, TVS Motor Company, and Ather Energy lead the charge with their cutting-edge electric scooters and motorcycles, catering to the diverse needs of consumers. Additionally, companies like Accell Group, with a notable presence in the Netherlands, also play a significant role in the Asian market, further enriching the electric mobility ecosystem. With competition intensifying and demand for sustainable transportation on the rise, these key players continue to drive innovation and shape the future of the electric two- and three-wheeler markets in Asia.

1.7.1 CASE STUDY: CHINESE EV MARKET

The Chinese electric two-wheeler market has undergone a remarkable evolution over the years, transitioning from its nascent stages to becoming a global leader in electric mobility. In the early stages, Chinese companies focused on producing basic electric bicycles to address local transportation needs and combat urban pollution. However, as the technology advanced and consumer preferences shifted towards more sophisticated vehicles, the market witnessed a surge in innovation. Companies like Yadea, Niu Technologies, and SUNRA emerged as frontrunners, introducing advanced electric scooters and motorcycles equipped with cutting-edge features such as smart connectivity, improved battery technology, and enhanced safety features. This evolution was driven by various factors including government support, technological advancements, and growing environmental concerns.

02 CURRENT STATE OF EV INDUSTRY AND MARKET IN PAKISTAN

The approval of the EVP in 2020 has encouraged private sector investment in the EV manufacturing in Pakistan. The fiscal incentives of the policy coupled with sizeable potential market size resulted in emergence of many Pakistan-based EV manufacturers. Till date, 32 manufacturers have been granted license by the Engineering Development Board (EDB) for indigenous manufacturing of EVs in Pakistan. All of these manufacturers have obtained license for the development of either electric two- or-three-wheeler, while few have been authorized to develop both types of vehicles. Another common trait amongst these licensed manufacturers is that most of them are Pakistan-based young private-sector companies that have been established after the approval of the EVP in 2020.

2.1 TRENDS IN EV MANUFACTURING INDUSTRY

Most of the EV manufacturing industry in Pakistan is concentrated in the segment for two- and three-wheelers. Additionally, ancillary/support industry has also started to emerge to provide indigenously developed parts and modules for the electric automotive sector. Most notably, some companies have been formed in the segment of battery pack manufacturing, while other sub-sectors of the support industry, such as motor manufacturing, have also started to emerge.

2.1.1 ELECTRIC TWO-WHEELER INDUSTRY

Industrial Players

Most of the players in the EV industry of Pakistan are from the two-wheeler segment. Of the 32 licensed EV manufacturers, 30 have developed or are at various stages of developing electric two-wheelers. Annex 2A provides a list of licensed electric two-wheeler manufacturers in Pakistan.

Characteristics

Most of the current electric two-wheeler variants developed indigenously share many attributes with their ICE-based counterparts that are widely driven across the country. Other than batteries, motors, and EV specific modules, the electric two-wheeler manufacturing sector is reliant upon the existing and already well-established parts and components ancillary industry for ICE-based two-wheelers. It allows the electric two-wheeler manufacturers to leverage the existing supply chain of parts and modules of current ICE-based two-wheeler sector. This approach yields several benefits. First, the low cost of locally available parts results in overall reduction in the price of the vehicle. Secondly, it allows the industry to avoid challenges associated with import of such items such as exchange rate fluctuations. Lastly, it enables existing repair centers to service and maintain the electric two-wheelers (other than EV specific parts). Table 3 highlights key characteristics of the current two-wheeler variants developed in Pakistan.

TABLE 3: CHARACTERISTICS OF TYPICAL ELECTRIC TWO-WHEELER VARIANTS DEVELOPED IN PAKISTAN

CHARACTERISTIC	VALUES
Purchase Price (USD)	500 – 1,000
Drive 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

The electric two-wheeler variants develop by most manufacturers possess similar technical characteristics as described in Table 3. There are also few electric two-wheeler manufacturers in Pakistan that offer vehicles that are often characterized under the 'luxury' segment. These two-wheelers offer more battery capacity, higher speed, and torque, and often have a unique sporty design. However, such vehicles are developed to target a specific niche in the two-wheeler market that is willing to pay a much higher upfront purchase price. Figure 6 illustrates selected electric two-wheeler models developed in Pakistan.

Production Capacity

Most of the already well-established ICE-based two-wheeler manufacturers have not ventured into the EV manufacturing sector. Therefore, most electric two-wheeler manufacturers in Pakistan are young companies or start-ups. Consequently, these electric two-wheeler manufacturers possess limited manufacturing and production facilities resulting in restricted roll-out of vehicles. Many of these manufacturers currently possess the capacity to develop less than a few thousand vehicles annually. Some manufacturers possess production capacity that is limited to a few hundred vehicles annually.[13]

13 Arshad, N. et al. (2021) PAKISTAN: ELECTRIC VEHICLES AND BATTERIES MARKET ASSESSMENT. rep. United States Agency for International Development. Available at: https://pdf.usaid.gov/pdf_docs/PA00XXDK.pdf (Accessed: 13 February 2024).

Compliance with Standards

Lack of sophisticated manufacturing facilities have limited the ability of the electric two-wheeler manufacturers to ensure compliance to international standards which is essential to the pave the way for exports. The non-EV specific parts, leveraged from ICE-based ancillary industry, utilized in electric two-wheeler manufacturing are often compliant with standards introduced by Pakistan Standards and Quality Control Authority. However, EV-specific parts, that include batteries, motors, and peripheral electronics, are typically not compliant with local or international standards. Furthermore, there are few advanced testing and characterization facilities in Pakistan that can be availed to ensure compliance to globally accepted standards.

User Acceptability and Gender Patterns in Two-wheeler Usage

The two-wheelers in Pakistan are largely driven by the male segment of the population due to deep-rooted social and cultural reasons. Since most ride sharing services employing two-wheelers are offered by the male segment of the population in Pakistan, women typically tend to shy away from availing such services. Furthermore, due to lack of lane discipline and frequent rash driving on roads, the two-wheeler riders are highly prone to accidents which is considered a discouraging factor for potential women two-wheeler drivers. Lastly, the typical eastern dresses worn by many women in Pakistan are deemed unfit for rising two-wheelers.

However, this trend is being challenged with the electric two-wheeler adoption. A category of electric two-wheelers, often referred as 'scooty', is gaining popularity amongst female drivers. The electric scooties are relatively smaller in size than typical electric two-wheelers and have reduced acceleration and weight. This allows convenient handling of the vehicle. Moreover, these vehicles can be driven with convenience by women wearing tradition dress.

The provincial governments in Pakistan have attempted to increase female ridership in the two-wheeler segment. For instance, the Government of the Punjab initiated the Women on Wheels project under which 700 two-wheelers were distributed amongst women in Pakistan along with imparting required training. However, efforts at such scale often do not have a sustainable and noteworthy impact.

Challenges

The upfront purchase price of electric two-wheelers remains a critical challenge. The price of a typical electric two-wheeler in Pakistan is almost twice the price of its gasoline equivalent. This is because the price of lithium-ion batteries in electric two-wheelers is more than half of the total price of the vehicle. To address this challenge, some manufacturers have retorted to employing lead-acid batteries which not only offer limited driving range but also add substantial weight to the vehicle as well as offer much lower battery cycles, implying frequent need for battery replacement.

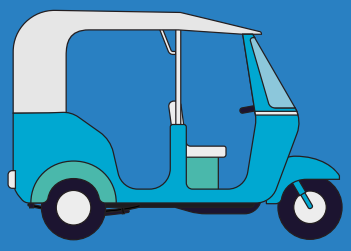
Figure 6: Illustration of selected electric two-wheeler models developed in Pakistan.

2.1.2 ELECTRIC THREE-WHEELER INDUSTRY

Industrial Players

Unlike the electric two-wheeler manufacturing sector in Pakistan, there are relatively few licensed companies in the electric three-wheeler segment. This is fundamentally due to higher complexities in e-three-wheeler manufacturing in contrast to two-wheeler manufacturing. Of the 32 licensed EV manufacturers in Pakistan, only 5 are developing electric three-wheelers. Annex 2B provides a list of licensed electric three-wheeler manufacturers in Pakistan.

5/32
licensed
EV manufacturers
in Pakistan
are developing
electric three-wheelers



Characteristics

The electric three-wheeler segment shares many traits with the electric two-wheeler sector in Pakistan. Like the electric two-wheeler industry, the electric three-wheeler sector, relies on local vendor industry for provisioning of non-EV specific parts and components due to similar reasons as mentioned above. However, unlike the electric two-wheeler market, the price of electric three-wheelers is three-four times the price of their gasoline counterparts. This is due to requirement for much larger battery capacity to prevent range-anxiety for the drivers. Due to utilization of existing supply chain of ICE-based three-wheeler segment for provisioning of non-EV-specific parts and components, the electric three-wheeler variants share many traits with their ICE equivalents. Therefore, the characteristics of most electric three-wheeler variants, developed by different manufacturers, closely resemble each other. Figure 7 illustrates selected electric three-wheeler models developed in Pakistan. Table 4 highlights key characteristics of the electric three-wheeler models developed indigenously.

TABLE 4: CHARACTERISTICS OF TYPICAL ELECTRIC THREE-WHEELER VARIANTS DEVELOPED IN PAKISTAN

CHARACTERISTIC	VALUES
Purchase Price (USD)	3,000 – 4,500
Drive 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

Production Capacity

Unlike the electric two-wheeler industry, the production capacity varies across a wide range in the electric three-wheeler segment. The existing well-established ICE-based three-wheeler manufacturers that have developed e-three-wheeler manufacturing lines possess sizable production capacity to the tune of thousand annually. However, there are some newly established companies that have ventured into the electric three-wheeler manufacturing segment. Such companies are often characterized by limited manufacturing capacity that is typically less than a few thousand vehicles annually.

Compliance with Standards

The electric three-wheeler industry is facing similar challenges in standardization as the electric two-wheeler manufacturing segment. Most of the non-EV specific parts in electric three-wheelers are compliant with locally developed standards, while the components of the electric drivetrain lack standardization. However, it has been observed that in contrast to the electric two-wheeler industry, the electric three-wheeler manufacturers typically employ better quality components in the electric drivetrain. One fundamental reason for this is that the three-wheelers need to be highly robust vehicles due to their much more frequent usage and larger load carrying requirements.

User Acceptability and Gender Patterns in Three-wheeler Usage

The three-wheelers are almost exclusively driven by the male segment of the population. This trend is likely to continue with the emergence of the electric three-wheeler sector. However, the GoP has announced certain incentivized schemes to promote e-three-wheeler adoption that set a fixed quota for prospective women drivers.

Challenges

The most critical challenge faced by the electric three-wheeler industry is the high upfront cost of the vehicle. The purchase price of most electric three-wheelers is at least three-to-four times the price of their ICE-based counterparts. This is primarily due to the requirement of larger battery capacities since these vehicles are solely utilized for commercial purposes and thus traverse much longer distances than privately owned passenger vehicles like the two- and four-wheelers. Furthermore, these vehicles are not designed to accommodate fast charging. This is because enabling fast charging results in further price escalation and rapid degradation of battery.

Figure 7: Illustration of selected electric three-wheeler models developed in Pakistan.

Swappable Battery-based vehicles

Some electric three-wheeler manufacturers have offered another approach to energizing the vehicles in contrast to conventional wired charging of fixed batteries. Under this approach, the cost of the vehicle is separated from the cost of the batteries. The owner of the vehicle purchases the vehicle excluding the batteries. The batteries are obtained on rental basis from a chain of franchisees just like the gasoline value chain. Through such an approach utilizing swappable batteries, the vehicle owners can purchase the vehicle at a price that is at parity with existing fossil fuel-based counterparts, while at the same time enjoy a lesser running cost. The entire process of the battery swapping can take place in less than a minute, thus removing the critical barrier associated with long charging time.

The ancillary industry supports the automotive manufacturing sector through provisioning of parts and components. In the electric two- and three-wheeler segments, the indigenous industry is supplying almost all non-EVs specific parts and components. Though there are handful of lithium-ion battery pack manufacturers and EV motor developers, the batteries and motors are still being imported at large due to the unavailability of required manufacturing expertise and capacities in the country.

2.2 TRENDS IN EV ANCILLARY INDUSTRY

2.2.1 BATTERY PACK MANUFACTURING INDUSTRY

Industrial Players

Pakistan has a well-established battery industry that is focused on development of lead-acid based energy storage solutions. The demand for lead-acid batteries in the ICE-based automotive sector, telecommunication sector, and power backup solutions such as uninterruptible power supplies (UPSs) is catered through indigenously developed energy storage solutions. The industry for the development and production of lithium-ion batteries is at a nascent stage in Pakistan. Over the recent years, few companies have been established that are manufacturing lithium-ion battery packs using imported cells. Due to the lack of maturation of the respective industry in the country, the e-mobility sector is reliant upon imported solutions that are not only costly but also have associated challenges such as after sales service.

Manufacturing Capacity

Most lithium-ion battery manufacturers currently possess limited roll-out capacity and lack sophisticated manufacturing equipment and expertise. The battery packs are assembled using imported cells. Currently, indigenous battery cell manufacturing appears to be out of reach in the short-term due to the fact that it requisites supply of rare-earth materials which have a highly monopolized market and cell manufacturing gains commercial viability at economies of scale.

2.2.2 ELECTRIC MOTOR MANUFACTURING INDUSTRY

State of the Current Motor Industry in Pakistan

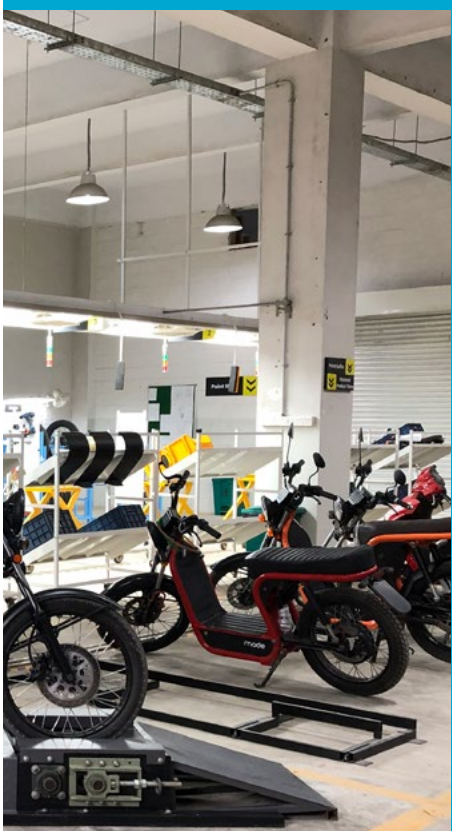
Pakistan has a well-established motor manufacturing industry that has been developing induction motors for the past several years. Motor manufacturing mainly takes place in Gujranwala and surrounding areas in Pakistan. Recently, the industry has commenced manufacturing of BLDC motors. These indigenously developed motors are used in a wide range of applications such as water pumps and electric fans. Currently, the motor industry in Pakistan lacs the capacity to design and develop motors for e-mobility applications.

Characteristics of the Current Motor Industry in Pakistan

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 percent and hence are not worthy for EV applications that require up to 95 percent efficiency. The current production process 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 second hand copper wires are used in manufacturing of motor winding.

Technical Capacity of the Motor Industry

The current motor industry in the country is reliant upon old designs that yield poor weight-to-power ration. The industry also faces scanty of skilled human resource (HR) to conduct research and development (R&D) into new and efficient designs and manufacturing techniques. As for adapting production to accommodate EV demand, most manufacturers believe that they can possibly reverse engineer over time (5-7 years) while designing might take longer. Since motors must operate between an optimal temperature range in order to maintain their efficiency, fan manufacturing industry has the potential to play an important role in the EV value chain.



Compliance with Standards

Most of the motors developed in Pakistan are not compliant with EV requirements and standards. The challenges with compliance to standards are further augmented by the lack of motor testing and characterization facilities

2.3 CONSTRAINTS IN THE EV MANUFACTURING SECTOR

Financing Constraints:

Limited access to financing options with affordable financing rates for setting up EV industry is a major barrier. The interest rate presently hovers around 23% and for any industry this high rate becomes a showstopper.

Policy and Regulatory Challenges:

Inconsistent government policies and regulations create uncertainty for manufacturers and investors. Lack of clear guidelines on incentives, subsidies, import tariffs, and emissions standards hinder investment and growth in the sector. Since EV is a cross disciplinary subject, close coordination is indispensable between departments and ministries of the federal and provincial governments as well as regulatory agencies.

Testing and Certification Requirements:

Stringent testing and certification requirements for EVs may pose challenges for manufacturers looking to enter the Pakistani market for quality products. 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 export market. Thus, many companies either develop sub-standard vehicles for local market or introduce imported vehicles from China which do not give any industrial uplifting to the EV value chain in the country.

Supply Chain Constraints:

Dependency on imports for components and limited local manufacturing capabilities contribute to supply chain challenges. Delays in component procurement, high import tariffs for certain components, and supply chain disruptions can hinder production and increase costs for manufacturers.

Skill Shortages:

The shortage of skilled workforce in the EV sector presents a barrier for industrial growth. Lack of training programs and educational opportunities limit the availability of qualified personnel for manufacturing, maintenance, and repair purposes.

2.4 REQUIRED HUMAN RESOURCE SKILLS FOR EV INDUSTRY

One of the key challenges faced by the current electric two- and three-wheeler industry is the absence of the required skilled Human Resource (HR). This can be partly explained by the lack sufficient funds to leverage the required HR as well as scarcity of personnel in the country with the required expertise. Therefore, it is crucial that the indigenous industry develops skills in the following domains:

Battery Technology:

The understanding of battery chemistry, energy storage, and battery management systems is crucial for engineers involved in designing, developing, and testing EV batteries. Skills in battery modeling, simulation, and optimization are also valuable for improving performance and efficiency in EVs.

Electric Powertrain Engineering:

A proficiency in electric motor design, power electronics, and control systems is essential for engineers working on electric powertrains. This includes expertise in motor sizing, thermal management, and integration with vehicle systems to ensure optimal performance, safety, and efficiency.

Charging Infrastructure:

Detailed knowledge of EV charging standards, protocols, and infrastructure design is necessary for professionals involved in planning, installing, and maintaining charging stations. Skills in grid integration, smart charging technologies, and interoperability are increasingly important as the EV charging network expands.

Energy Storage Systems:

Deep understanding of energy storage technologies beyond traditional batteries, such as supercapacitors and fuel cells, is valuable for engineers working on advanced energy storage systems for e-vehicles. Skills in energy conversion, efficiency analysis, and hybridization techniques contribute to the development of next-generation EVs with improved range and performance.

Sustainable Supply Chain Management:

Proficiency in sustainable sourcing, material selection, and supply chain optimization is essential for professionals involved in procuring components and materials for electric vehicle manufacturing. Knowledge of environmental impact assessment, lifecycle analysis, and ethical sourcing practices helps mitigate environmental and social risks in the supply chain.

Electric Vehicle Diagnostics and Maintenance:

Technical expertise in diagnosing and troubleshooting EV systems, including battery health monitoring, electric drivetrain diagnostics, and software updates, is critical for technicians and personnel in servicing industry. Skills in e-vehicle repair, maintenance procedures, and safety protocols ensure the reliability and longevity of EVs throughout their lifecycle.

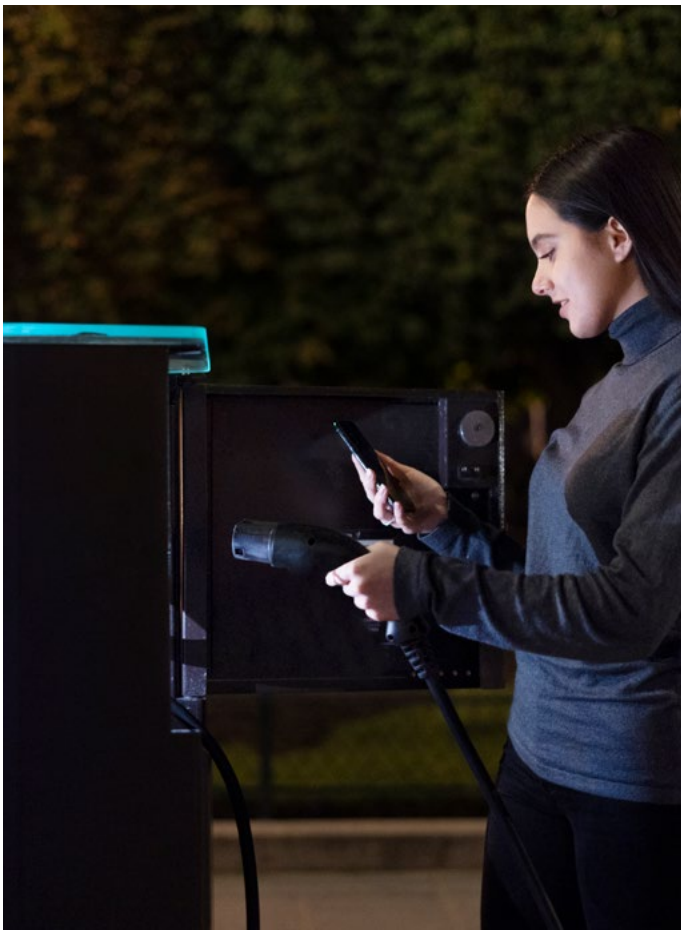
Regulatory Compliance and Standards:

Understanding regulatory requirements, safety standards, and certification processes relevant to EVs is essential for professionals involved in product development, testing, and compliance. Knowledge of emissions regulations, vehicle safety standards, and cybersecurity protocols helps ensure regulatory compliance and market acceptance of electric vehicles.

Data Analytics and Telematics:

Proficiency in data analytics, machine learning, and telematics systems is valuable for extracting insights from vehicle telemetry data, optimizing performance, and enhancing user experience. Skills in data visualization, predictive maintenance, and remote diagnostics support continuous improvement and innovation in the e-mobility sector.

2.5 KEY EV MARKET BARRIERS



Elevated Initial Costs:

One of the major obstacles hindering the widespread adoption of EVs in Pakistan is the significantly higher upfront expenditure associated with purchasing these vehicles compared to their traditional counterparts. This cost differential renders EVs financially inaccessible to a considerable portion of the population, thus constraining their market penetration to a wealthier demographic.

Range Anxiety and Infrastructure for Charging:

The prevalent concern of 'range anxiety', which pertains to the fear of an EV running out of power before reaching a charging station, poses a significant deterrent to potential buyers. This issue is particularly pronounced in Pakistan due to the inadequate infrastructure for charging, dissuading many prospective customers from considering EVs as a feasible alternative to conventional fuel-based vehicles.

Electricity Shortage and Battery Charging:

The existing shortfall in electricity supply directly impacts the practicality of EVs in Pakistan. Despite the grid's overall capacity being sufficient, revenue-driven load management in numerous areas poses challenges for operating charging stations. Additionally, the prolonged charging durations and limited driving range per charge contribute to the perception of EVs as less convenient, further impeding their adoption.

Restricted Model Options and Availability:

The limited availability of EV models in Pakistan constrains consumer choice and preference. The dearth of diverse options tailored to specific requirements, tastes, or financial constraints compared to traditional vehicles could deter potential buyers due to a lack of appealing alternatives. While more than 30 EV manufacturing licenses have been granted by the Engineering Development Board (EDB), manufacturers have been sluggish in introducing new models to the market.

Skilled Workforce for EV Maintenance:

The transition to EVs necessitates specialized skills for maintenance and repair, which Pakistan currently lacks. This shortage of trained professionals may lead to escalated maintenance expenses and discourage prospective EV buyers. Moreover, manufacturers encounter difficulties in recruiting skilled personnel proficient in batteries, high-efficiency motors, and power electronics.

Policy Inconsistency and Regulatory Hurdles:

Inconsistent governmental policies and a dearth of clear regulations create an atmosphere of uncertainty for both consumers and manufacturers. This ambiguity can impede investments in EV infrastructure and technology, thereby hampering the growth of the EV market. Notably, uncertainties persist regarding the entity responsible for battery safety and the standardization of charging protocols, exacerbated by conflicting regulations between federal and

Financing and Accessibility of Loans:

Access to financing options for purchasing EVs is limited in comparison to traditional vehicles, thereby posing a financial barrier to a significant portion of the population, including consumers and small businesses. Furthermore, high interest rates and capital costs render EVs less appealing to potential buyers.

Supply Chain and Manufacturing Limitations:

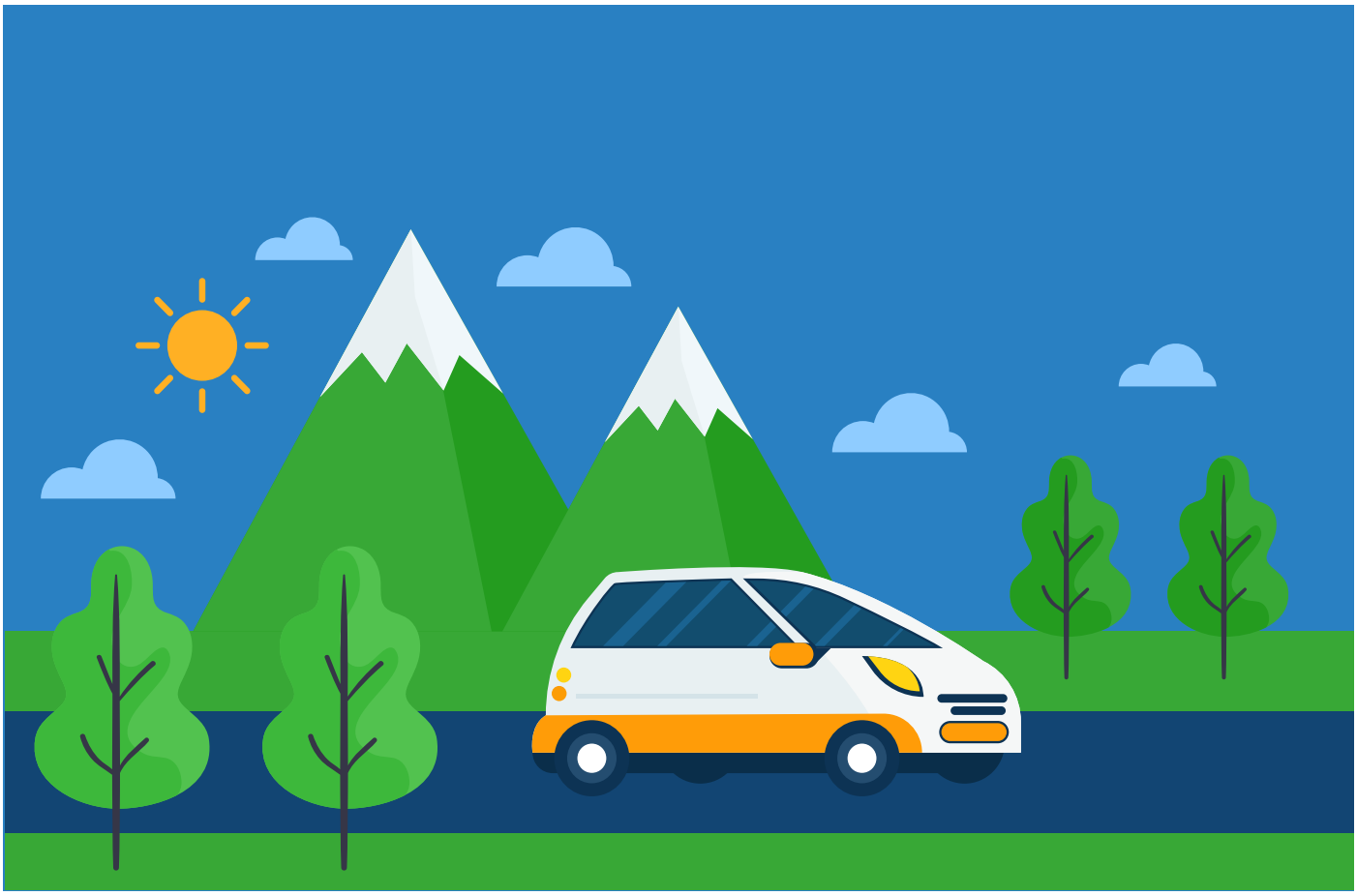
Pakistan encounters challenges in establishing a robust supply chain for EV components and establishing local manufacturing facilities. These hurdles can result in increased costs and dependencies on imports, rendering EVs less competitive. The local manufacturing of battery packs and motors is crucial for the success of EVs, necessitating a reduction in import duties on components to incentivize local production.

Disposal and Recycling of Batteries:

The disposal and recycling of used EV batteries present environmental and logistical challenges in Pakistan. In the absence of proper facilities and regulations, improper battery disposal could lead to adverse environmental consequences. Currently, there are no policies or regulations governing the proper disposal of EV batteries.

Public Perception and Awareness:

There is a pressing need to shift public attitudes towards EVs and enhance awareness regarding their economic and environmental advantages.



03 SHORT–TERM OPPORTUNITIES IN THE EV SECTOR

The demand for EVs in Pakistan has been largely driven by swift increase in gasoline prices in the country over the past two years. However, this demand has not been able to proportionately translate into EV adoption due to various market barriers. The most notable of these barriers include deficiency of intra- and inter-city fast charging facilities, high upfront purchase price of vehicles, and limited presence of repair and maintenance centers. The ability of EV and parts manufacturers to provide effective solutions to these barriers provides them business and commercial opportunities. The high demand in the country for cost effective e-mobility solutions and a sizeable potential market share has provided EV and parts manufacturers with valuable market opportunities. Keeping in view the current state of the EV manufacturing sector, marked by limited capital as well as manufacturing and R&D capacities, the existing and prospective manufacturers need to strategically plan and utilize their available resources to capture maximum market share. This chapter provides insights on various opportunities available to the EV and parts manufacturers in the short-term. The 'short-term' is defined in this report as a timespan of five years.

3.1 OPPORTUNITIES IN THE TWO-WHEELER SEGMENT

The electric two-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 almost two million registered two-wheelers in the country which are a potential candidate for transition towards EVs. Secondly, the automotive parts manufacturing industry for the ICE-based two wheelers in Pakistan has achieved sufficient self-reliance and economies of scale. This has established a dependable and cost-effective supply chain of parts and components which can be leveraged by the EV industry for application of non-EV-specific parts such as tires, chassis, and brakes etc. In particular, there are two areas in the electric two-wheeler segment that can provide opportunities for manufacturers to capture a larger market share in the short-term.

Retrofit Kits:

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. 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.

3.1.1 BRIDGING GAPS IN THE SUPPLY CHAIN

Leveraging existing automotive parts industry:

Other than the EV-specific parts, that include battery, motor, and associated electronics, the electric two-wheelers can be developed using the existing well-established supply chain of ICE-based automotive parts and components. Over the past few decades, the ancillary industry supplying automotive parts for the ICE-based two-wheeler segment has achieved economies of scale and sufficient self-reliance. It has enabled the ancillary industry to supply automotive parts at a cost-effective price with reliable quality. The current and prospective electric two-wheeler manufacturers can leverage the indigenous ICE-based ancillary industry for provisioning of non-EV-specific parts. Such an approach will enable the electric two-wheeler manufacturers secure a reliable supply chain of automotive parts and reduce the cost of the vehicle.

3.2 OPPORTUNITIES IN THE THREE-WHEELER SEGMENT

The highest demand for EVs is in the segment for three-wheelers. According to a survey involving more than 500 ICE-based three-wheeler drivers, the daily profit of ride hailing services is USD 3-4. The swift increase in gasoline prices in Pakistan over the past two years has compelled three-wheeler drivers to increase ride fare proportionately which has resulted in reduced ridership and thus decrease in income. The electric three-wheelers offer up to 70 percent reduction in operating expense in contrast to their ICE-equivalents. However, the major challenges in electric three-wheeler adoption are high upfront purchase cost of the vehicles and lack of on-road fast charging facilities. Addressing these challenges provides opportunities to the electric three-wheeler and parts manufacturers. To this end, this report identifies the following key opportunities for automotive manufacturers and charging services providers in the short-term:

Swappable battery-based electric three-wheelers:

The swappable battery-based electric three-wheelers provide an effective solution to the high upfront purchase price of their counterparts with fixed batteries. 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 3-4 minutes. The batteries under this model are owned by the charging services providers and not the vehicle operator. The battery swapping regime enables, the end-users to purchase an EV at a price that is at par with ICE-equivalents while at the same time reap benefits due to lower operational expense incurred by the electric drive train. 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.

3.2.1 BRIDGING GAPS IN THE SUPPLY CHAIN

In addition to the opportunities present for the electric three-wheeler manufacturers in the battery swapping regime, there are opportunities available for leveraging existing ICE-based ancillary industry for the supply of automotive parts and components. An electric three-wheeler can be retrofitted in a similar manner to two-wheelers and can be converted into all-electric vehicle. In the short-term, where are most current electric three-wheeler manufacturers are faced with challenges such as limited capital, few advanced vehicle manufacturing facilities, and unavailability of skilled human resource, the existing ancillary industry for ICE-based three-wheeler parts can be utilized for the provisioning of non-EV specific parts and components. In the medium to long-term, as the electric three-wheeler industry matures in Pakistan, the reliance on ICE-based three-wheeler ancillary industry for supply of parts and modules can be reduced through phased indigenous research and development.

3.3 OPPORTUNITIES IN THE BATTERY PACK MANUFACTURING – SECURING ACCESS TO RAW MATERIALS

3.3.1 GAPS IN SUPPLY CHAIN OF RAW MATERIALS

Battery is the most critical component in an EV, constituting almost half of the total cost of the vehicle. Often lithium-ion or other lithium-based derived battery chemistries are employed in EV applications. The lithium is a rare earth material with few mines located at a handful of locations globally. As a consequence, the lithium mining sector is high monopolized and access to this rare earth material requires government-to-government engagements. Furthermore, companies having lithium also typically do not trade the raw material as it decreases the value added to the export. Instead finished products employing lithium, such as batteries or cells, are exported. Therefore, in the short-term it is not possible to establish cell manufacturing industry in Pakistan as it requires access to rare earth materials, especially including lithium and nickel.

In the short-term, the indigenous battery back manufacturers will need to rely on imported lithium-ion cells. However, the global market for lithium-ion cells is also not very friendly to early or small-scale battery pack manufacturers. There are few lithium-ion cell manufacturers globally. Most lithium-ion cell manufacturers only engage in business deals involving cell order to the tune of millions. This creates challenges for young battery pack manufacturers to directly purchase cells from these manufacturers. Therefore, many new battery pack manufacturers have to rely on import of cells from third party vendors. This creates few challenges such as access to high quality cells and claims for warranty and replacement of potential cells.

3.3.2 RECOMMENDED SHORT-TERM APPROACH FOR BATTERY PACK MANUFACTURERS

Pakistan has a sizeable opportunity for indigenous battery pack manufacturing through importing cells from the international market. The imported battery cells can be assembled into a battery pack indigenously and the battery management system (BMS) can be locally developed that batter suits the unique requirements of two- and three-wheeler market in Pakistan. With very few lithium-ion battery pack manufacturers currently in Pakistan and growing demand for lithium-ion based energy storage solutions, there exists a valuable opportunity for investment in this emerging industrial sector.

Caution of two-wheeler, three-wheeler and battery pack manufacturers:

Emerging battery pack manufacturers often tend to utilize lower quality cells that can be purchased with relative convenience from vendors or middleman. However, these tier-2 or tier-3 cells create many challenges when assembled into a battery pack and utilized in e-mobility applications. Such cells often yield considerably lower lifecycles and thus end-users need to frequently incur battery replacement costs. Furthermore, the mileage offered by the batteries employing such cells drastically decreases in contrast to batteries utilizing high quality or tier-1 cells. Moreover, such cells are also more suspectable to faults and fire incidents. Challenges due to poor quality of cells during early stages of EV adoption in Pakistan or any other country can have negative impact on public perception at large regarding viability of e-vehicles. While tier-2 or tier-3 cells also carry a relatively lower price in contrast to tier-1 cells and are often leveraged to reduce the upfront purchase price of the vehicles, application of these cells can create challenges for manufacturers as well as end-users in the medium-to-long-term and the at the same time reduce end-user confidence, especially amongst prospective early adopters of EVs.

3.4 STANDARDIZATION REQUIREMENTS FOR THE SHORT-TERM

Standardization of the entire EV value chain, especially including e-vehicles and associated charging infrastructure, is one of the most crucial aspects in the development of the EV sector in Pakistan. The 'standards', in the context of automotive sector, refer to set of mandatory requirements, characteristics or rules that must be followed across the entire vehicular value chain or its specific segments. While a myriad of standards governing electric mobility have been developed globally by multiple Standards Development Organizations (SDOs), it is of paramount significance that these standards must fulfil indigenous requirements and conditions. Standards in the EV value chain ensure compliance with local, regional, and globally accepted practices as well as govern and regulate the respective sector.

Standardization ensures interoperability between vehicles, charging infrastructure and vehicular parts and components, enables national and international trade of vehicles, their parts, and components, and charging hardware, allow regularization through establishing benchmarks, and ensure Safety of the passengers, vehicles and vehicular parts and components as well as provide a reasonable minimum level of quality products and services to the consumers.

The Government of Pakistan has commenced the process of standardizing the EV sector. The Cabinet Committee for Disposal of Legislative Cases on January 6th, 2024, approved safety standards for the automotive sector including EVs. Furthermore, Pakistan Standards and Quality Control Authority (PSQCA) has established a Technical Committee on Electrically Propelled Road Vehicles (TC-05) to develop EV-specific standards. This TC has already developed and adopted few standards for the electric power train for electric vehicles. While, the process of standardization is ongoing in Pakistan, it is crucial that a mandatory framework for standards must be adopted at earliest to harmonize the EV sector. In the short-term, it is crucial that the following standards must be developed and adopted by all manufacturers:

1. **Charging standards** for communication protocol(s) and charging connector
2. **Battery cell standards** that define quality/tier of the cells, their lifetime, type/category, and parameters such as SoH, SoC etc.
3. **Safety Standards** for the passengers, vehicle, charging standards and especially including components of the electric drive train.
4. **Vehicle Performance** standards such as top speed, minimum range etc
5. **Environmental Standards** including IP rating of the drivetrain, and mechanical shock and vibration tolerance etc.

The standardization is one of the most important factors determining EV adoption in the country. However, it is important to note that since the indigenous industry is at a nascent stage of development, a stringent standardization and regulatory regime can create barriers for the local industry to develop and introduce their solutions in the market. Therefore, it a prudent approach is introduce a minimum mandatory standardization and regulatory regime and as the industry gradually gains maturity, more standards can be introduced to better regulate the sector.

3.5 OPPORTUNITIES IN CHARGING SERVICES PROVISIONING SECTOR

The development of charging infrastructure and introduction of EVs on roads in often referred as 'chicken or the egg' causality dilemma. It is often argued whether required charging infrastructure should be established to encourage EV adoption or vice versa. In the context of Pakistan, a prudent approach shall be establishing a bare minimum network of charging infrastructure to prevent 'range-anxiety' or fear or running out of battery power while on road. The establishment of the minimum mandatory network of charging infrastructure will then encourage EV adoption and provide more commercial opportunities to the charging services providers.

During the short-term, the charging service providers need to identify strategic intra- and inter-city locations where EV drivers will need fast charging. These strategic locations can potentially include service areas along key national highways and motorways. A report by Lahore University of Management Sciences (LUMS) identifies 16 locations across motorways and highways of Pakistan where if fast charging infrastructure is deployed, it can enable commute across most large cities within the country.[13] Such strategic locations across key highways provide an opportunity to the prospective charging services providers. Furthermore, similar strategic locations can be identified within large cities that are suitable for development of fast charging infrastructure in the short-term. These
intra-city locations can include large shopping malls or markets with sizeable customer base.

13 Arshad, N., Javed, M.A., Arslan, M.M. and Khan, H.O.A. (2021) Developing Electric Vehicle Charging Infrastructure Across Motorways and Highways of Pakistan. publication. Ministry of Climate Change and Environmental Coordination. Available at: https://lei.lums.edu.pk/index.php/ev-charging-infrastructure/.

3.6 OPPORTUNITIES FOR EXPORT

There are several factors that determine the opportunities for export of EV solutions. Some of these important factors include manufacturing capacity of the local industry, standardization requirements in the targeted country(s), and the ability to effectively market homegrown solutions. Many countries have their own unique standardization requirements to introduce products that are better suited to meet unique local requirements. However, in general the standardization requirements of each country fall undert the umbrella of globally accepted standards that have been developed Standards Development Organization (SDOs) such as International Electrotechnical Commission (IEC), International Organization for Standards (ISO), and Underwriters Laboratories (UL) amongst others. For the electric two- and three-wheeler industry in Pakistan to export their solutions, standardization requirement for each country needs to be fulfilled.

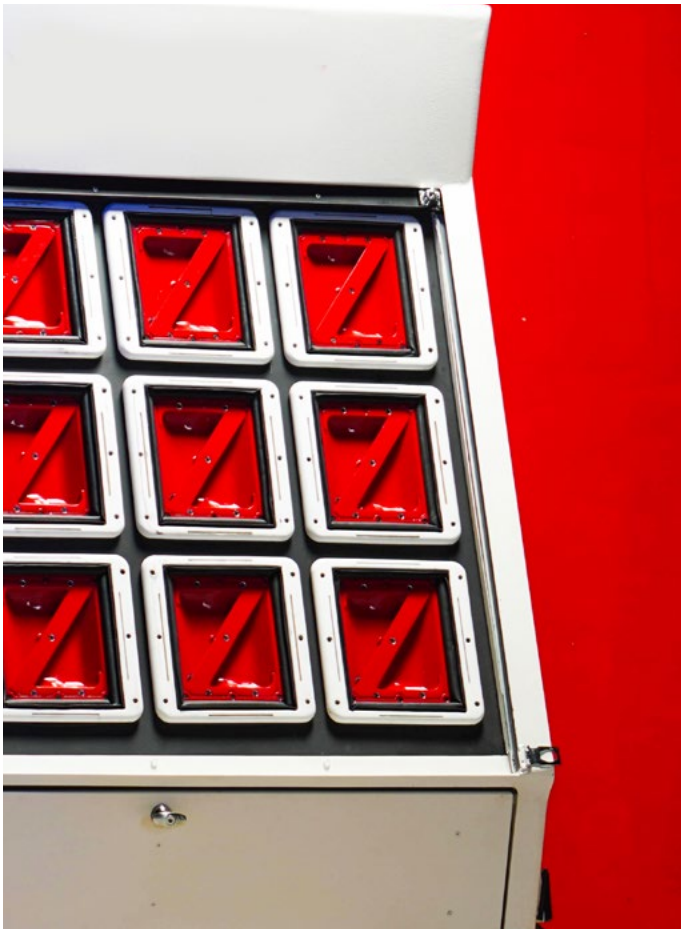
04 MEDIUM-TERM OPPORTUNITIES IN THE EV SECTOR

The medium-term in this report refers to the period from the fifth year to the tenth year from the present. It is assumed that in the short-term, i.e., over the next five years from the current point in time, the indigenous EV and parts manufacturers have benefitted from the opportunities mentioned in the preceding section. It is further assumed that while capitalizing the opportunities in the short-term, the EV industry in Pakistan has progressed in several aspects, including the development of skilled human resources, vehicle design, research and development, and overall growth.

It is expected that over the next five to ten years, the demand for e-mobility solutions from the two- and three-wheeler segment would have evolved relative to the present-day context. The evaluation of demand can potentially include more aspiration for EVs and higher degree of sophistication of the e-mobility solutions. There are multitude of factors that will shape the demand for EVs in the medium-term. These factors can include differential between OPEX and CAPEX of EVs in contrast to their ICE-equivalents, transformation of the global trends in the transportation system, and national and international regulations on mitigating GHG emissions. The demand for the e-mobility solutions in the medium-term will provide opportunities for the manufacturing sector. Therefore, the EV and parts manufacturers will need to ensure that they possess the required capacities to meet the projected demand and thus make most from the available market opportunities. In order to avail the medium-term opportunities, the manufacturing sector will need to strategically mature their various capacities through collaborations, and engagements with national and international players in the EV sector. To this end, this report identifies the following opportunities for the EV and parts manufacturers in the medium-term and provides recommendations to optimally benefit from them.

4.1 OPPORTUNITIES IN THE BATTERY MANUFACTURING SECTOR

In the medium term, the domestic industry is anticipated to have reached a mature state, resulting in a considerable rise in the demand for EVs compared to the present time. Therefore, it is essential to ensure the presence of a homegrown industry dedicated to the production of battery cells and packs, supported by a resilient and dependable supply chain.



It is important to note that in the next five to ten years a sizeable number of electric two- and three-wheelers are projected to be on roads, which requires presence of an indigenous well-established battery cell manufacturing industry. This is because during this period sole reliance on international vendors for aftersales services of battery cells will become highly unviable. However, in the medium-term direct access of indigenous cell manufacturers to the rare earth metals employed in battery cell manufacturing seems unlike due to the highly monopolized nature of market for these raw materials. Thus, the cell manufacturing industry in Pakistan will need to secure dependable supply chain of rare earth materials.

4.1.1 SECURING ACCESS TO RAW MATERIALS

Partnership with International Battery Pack Manufacturers:

Other than the EV-specific parts, that include battery, motor, and associated electronics, the electric two-wheelers can be developed using the existing well-established supply chain of ICE-based automotive parts and components. Over the past few decades, the ancillary industry supplying automotive parts for the ICE-based two-wheeler segment has achieved economies of scale and sufficient self-reliance. It has enabled the ancillary industry to supply automotive parts at a cost-effective price with reliable quality. The current and prospective electric two-wheeler manufacturers can leverage the indigenous ICE-based ancillary industry for provisioning of non-EV-specific parts. Such an approach will enable the electric two-wheeler manufacturers secure a reliable supply chain of automotive parts and reduce the cost of the vehicle.

South Korea, China, and Japan currently dominate the global battery market. Four battery cell manufacturers in China, three in South Korea, and three in Japan account for 90% of the global market. Many of these major cell manufacturers benefit from direct access to the monopolized rare earth metals mining sector, which is often facilitated through long-term government-to-government agreements.

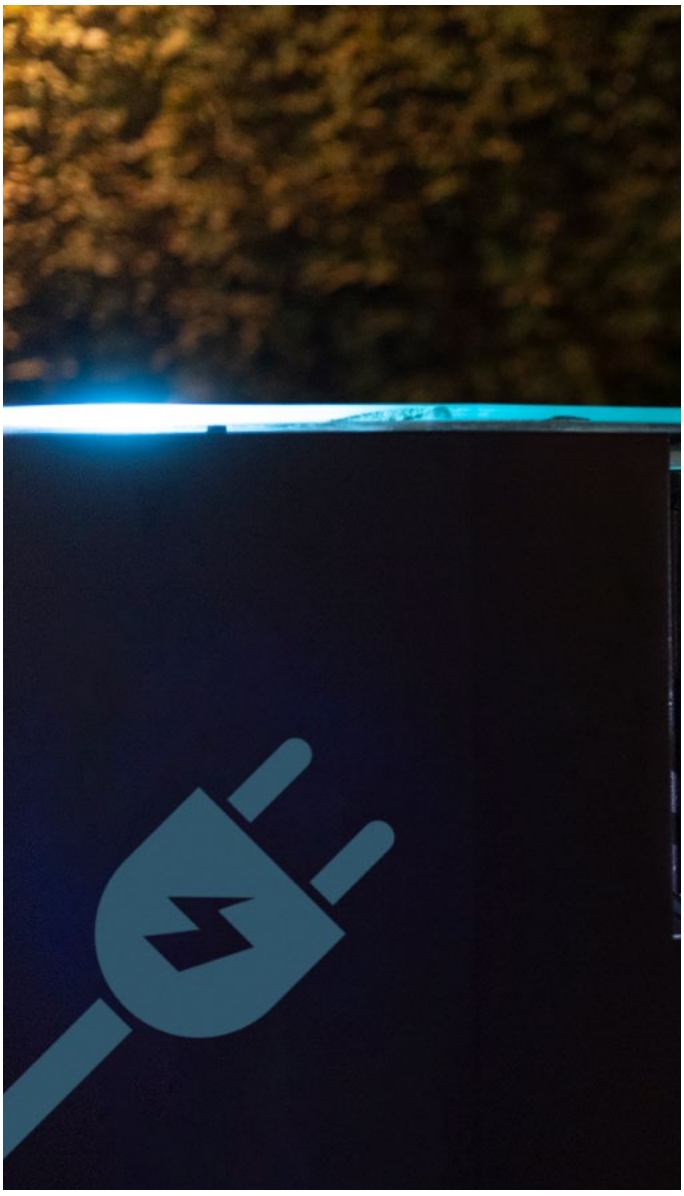
Private sector companies in Pakistan can establish cell manufacturing industry in the country in the medium-term through forming partnerships with existing global giants in the respective sector. These partnerships can be formed in the following, but not limited to, ways:

1. Foreign Direct Investment: Under this model international companies can establish business operations or acquire assets in a Pakistani company. It generally entails technology and management interventions in addition to financial investment.
2. Joint Venture: Through a joint venture indigenous and internal companies can establish cell manufacturing facilities in Pakistan through shared investment and equity.
3. Technology Transfer/ Equity-for-Technology: In this mode of partnership, often one party (the licensor) grants another party (the licensee) the rights to use, manufacture, sell, or further develop a specific technology, product, or intellectual property. The licensor typically retains ownership of the technology or intellectual property and receives compensation, such as royalties, equity, or upfront payments, from the licensee for the rights granted.

Establishing cell manufacturing industry in Pakistan through partnerships with existing well-established international players in the respective sector can yield multitude of benefits. First, these collaborations can enable businesses in Pakistan to promptly bolster their technological, human resource, and manufacturing capabilities. Secondly, it reduces risks for indigenous manufacturers associated with development of emerging technologies as they can leverage proven solutions from licensors. Moreover, these partnerships reduce valuable time and capital that otherwise would have been required for research and development. Most importantly, these partnerships can enable Pakistani companies gain access to crucial rare earth materials and other raw materials from their international partners.

Development of Advance Battery Pack Technologies:

In the short-term the manufacturers are expected to achieve fundamental capacities in battery pack manufacturing as mentioned in the preceding section of this report. The medium-term provides an opportunity to focus on optimizing battery performance through integration of data-driven and IoT-based techniques and technologies. Therefore, the period from the next fifth year to the tenth year provides an opportunity for battery pack manufacturers to develop capacities in the following areas:



1. Smart Battery Management System Design and Development: The enduring disparity in purchase prices between EVs and their ICE counterparts is poised to pose a persistent challenge for manufacturers in the medium term. This is primarily because the battery pack(s) are projected to occupy a substantial share in the total cost of the e-vehicles. Design and development of smart battery management system (BMS) provides an opportunity for the manufacturers to optimize and control individual cells inside a battery pack in contrast to the currently employed typical BMS that has the capacity to optimize performance of battery pack as a whole. Therefore, a smart BMS performs almost the same function that a typical BMS performs but has the capacity to do it at cell level. Application of smart BMS results in improved battery and vehicle performance, increased life of battery pack, reduced faults, and curtailed operational expense. Indigenous development of smart BMSs, that are designed keeping in view unique requirements of the two- and three-wheeler segment in Pakistan, is valuable opportunity for manufacturers in the medium-term. However, it is important to note that such solutions need time and extensive research and development efforts for maturation. The Pakistan-based battery pack and two- and three-wheeler manufacturers can leverage experience gained during the short-term to achieve capacities to develop these smart BMSs.

4.2 OPPORTUNITIES IN THE MOTOR MANUFACTURING SECTOR

In contrast to the mature motor industry in Pakistan focused on electric fans and water pumps, the sector dedicated to the manufacturing electric motors for e-mobility applications demands significantly greater expertise, manufacturing capabilities, and investment in research and development. Unlike the brushed DC motors, BLDC motors, and induction motors, e-mobility applications necessitate high-performance motors that typically achieve efficiency levels of up to 95%. Therefore, the motors employed in EVs need to possess a superior power-to-weight ratio, compactness, and deliver exceptional energy efficiency. These requirements necessitate establishing state-of-the-art manufacturing facilities, availability of skilled HR, and dependable supply chain of raw materials. Furthermore, the electric motors employed in EVs typically need to abide by a stringent standardization and regulatory regime and therefore, require testing and characterization facilities. The high-performance motors need a matured associated electronics industry for the provisioning of controllers such variable frequency drive (VFD) and variable speed drive (VSD) which is currently not well-established in Pakistan. Indigenous EV manufacturers expect that it will take a minimum of 5-7 years for the motor industry in Pakistan to mature sufficiently to fulfill the demands of electric two- and three-wheelers in the country. A prudent approach for the potential electric motor manufactures will be to establish partnerships, on similar pattern(s) as detailed in section 5.1, to expedite the maturation of respective industrial segment. These collaborations will yield several benefits such as reduced research and development time and cost, lower risks attributed with commercialization of new technologies, securing of supply chain for raw materials, and training of HR amongst others. Therefore, it is imperative for aspiring electric motor manufacturers targeting EV applications to promptly and strategically devise their plans for product introduction in the medium term.

4.3 OPPORTUNITIES IN THE SWAPPABLE BATTERY-BASED TWO-WHEELER MANUFACTURING

The two-wheeler segment in Pakistan mostly consists of privately owned vehicles that are utilized for non-commercial purposes. There are almost 26 million registered two-wheelers in Pakistan, representing 83% of all vehicles in the country. The experts in the e-mobility sector widely believe that the swappable battery-based approach for vehicular charging is most suited to commercial vehicles that traverse considerably more distance per day compared with privately owned vehicles utilized for non-commercial purposes. This is because long charging downtime of vehicles with fixed batteries considerably reduces their viability for commercial purposes. It is estimated that about 2% of the two-wheelers in Pakistan are utilized solely for commercial purposes such as ride-hailing services, postal services, and food delivery etc. Thus, the 0.5 million two-wheelers, representing 2% of the commercially operated two-wheelers, are a potential candidate for transition to EVs.

4.4 STANDARDIZATION REQUIREMENTS FOR THE MEDIUM-TERM

The short-term provides opportunities to the automotive and parts manufacturer for upgrading their manufacturing facilities and establishing testing and characterization facilities. During the medium-term, the development and manufacturing capacities of the indigenous industry are expected to considerably increase. These enhanced capacities will enable the EV manufacturing sector to ensure compliance with international standards that are accepted across most countries. A report by the National Renewable Energy Laboratory lists international standards for electric two- and three-wheelers, including safety, electric, environment durability, and performance parameters.[13]

This report further details test conditions under which compliance to standards must be ensured. Furthermore, the report highlights battery and charging standards, including swappable battery specifications, that are essential for the electric two- and three-wheeler industry in Pakistan. Ensuring compliance to universally accepted standardization regime will yield multi-dimensional benefits for the industry that include development of better-quality solutions, interoperability with global industry, enhanced consumer satisfaction, and further opportunities for export amongst others.

13 https://www.nrel.gov/docs/fy24osti/87955.pdf

Development of Testing and Characterization Facilities

Compliance to globally accepted standardization regime necessitates presence of state-of-the-art testing and characterization facilities. Most global SDOs have elaborated stringent requirements under which tests/characterization of the products must be performed to ensure compliance with the standards. There are very few testing/characterization facilities currently in Pakistan that possess the requires capacity to certify industrial products for compliance with standards. To this end, the EV industry and relevant public sector entities can jointly establish advanced testing/characterization facilities through public-private partnership that can certify e-mobility products/solutions for compliance with international standards.

4.5 OPPORTUNITIES FOR EXPORT

The degree of compliance by the indigenous manufacturers to the globally applicable standards will be the most important factor determining export potential. Each country has its own standardization requirement for the automotive sector, which typically falls under the umbrella of global standardization regime by SDOs. Therefore, the sale of two- and three-wheelers in most countries is contingent upon fulfillment of standardization requirements. If Pakistan-based EV manufacturers can ensure compliance with to a large extent with these standards, the number of countries with prospects of export will substantially increase.

It is expected that during the medium-term, the indigenous manufacturers will have developed the capacity to ensure compliance with all local and many international standards. This will open a sizeable export market for electric two- and three-wheeler manufacturers from Pakistan in South Asian and Southeast Asian countries that have a large two- and three-wheeler segments. It is important to note that these countries have comparable two- and three-wheeler segments with Pakistan in terms of key characteristics of the vehicles. Furthermore, many countries in South America can also serve as a potential export market for Pakistan-based electric two- and three-wheeler manufacturers due to similar reasons. The European and North American markets may not be suitable for export during the medium-term due to more stringent standardization needs and quality of the products.

05 LONG-TERM OPPORTUNITIES IN THE EV SECTOR

Pakistan has the potential to emerge as a prominent export hub for two and three-wheelers in the long term. However, realizing this potential necessitates a thorough examination of the requirements of potential export markets. Each export market presents its unique set of challenges and opportunities. A distinctive advantage for Pakistan lies in the similarity of challenges faced by many African and Asian markets. Consequently, vehicle designs and infrastructure suitable for Pakistan may also prove effective in these comparable markets. Additionally, Pakistan can capitalize on its strengths in manufacturing and the service industry to deliver superior vehicles tailored for export markets. The following key interventions can equip Pakistani companies for success in export markets.

5.1 OPPORTUNITIES IN EV DESIGN INDUSTRY

The popularity of two and three-wheelers in Pakistan stems from their affordability in terms of upfront costs and maintenance. Traditionally, vehicle designs have been influenced by the CD-70 motorcycle and rickshaw designs from the 1960s, with minimal alterations over the decades. However, the transition to electric powertrains necessitates significant design changes for both Electric Two-Wheelers (E2W) and Electric Three-Wheelers (E3W). Design considerations such as weight distribution, aerodynamics, and modularity are crucial for achieving mass affordability and energy-efficient operations in electric vehicles. Battery weight necessitates positioning as close to the ground as possible to maintain stability during turns, which is challenging with the current CD-70 motorcycle design. Furthermore, aerodynamic shapes are essential for maximizing energy efficiency. Additionally, vehicle materials must strike a balance between lightweight construction and durability to withstand rough terrain, high temperatures, and heavy loads.

Currently, Pakistan faces a shortage of human resources with expertise in vehicle design. While some engineering programs and arts colleges offer courses in product design, there is a lack of dedicated programs in vehicle design. Such programs should encompass not only engineering principles and aesthetics but also materials science to meet design and affordability requirements. Establishing diploma or degree programs in vehicle design is imperative to ensure an adequate workforce for new design developments.

5.2 OPPORTUNITIES IN EV SOFTWARE INDUSTRY

Software plays an increasingly pivotal role in electric vehicles, constituting a significant portion of their intellectual property. While historically a small component of vehicle costs, software now comprises up to 30% of the total price, a figure expected to rise further with advancements in automation, electronics, and artificial intelligence. Beyond in-vehicle software, additional software is required for managing vehicle infrastructure and fleet operations. This includes systems for vehicle communication, battery and thermal management, infotainment, motor control, and performance optimization.

Vehicular software development is a highly sought-after skill globally, with demand outstripping available talent. Pakistan's thriving IT industry positions it well to transition into this domain. However, there is a notable shortage of skilled professionals in this segment, attributable in part to enrollment shortfalls in computer engineering and electrical engineering programs nationwide. Unlike traditional computer science and information technology programs, vehicular software development demands expertise in both hardware and software. Therefore, merely upskilling graduates in these fields may not suffice. To address this shortage, Pakistan must attract qualified students to computer engineering and electrical engineering programs. However, this process will take time, as new graduates typically require 4-5 years before becoming industry-ready. Nonetheless, bridging this skill gap is essential for nurturing the vehicular software industry in the country.

06 CONCLUSION: RECOMMENDATIONS AND THE WAY FORWARD

This report extensively discusses the opportunities available to the indigenous electric two- and three-wheeler manufacturers Pakistan and provides a roadmap to reap them optimally and strategically. Besides mentioning these opportunities at length, there are some additional measures that can determine the success of the EV sector in Pakistan. Some of these steps need to be taken by the manufacturers while others need to be fulfilled by the relevant public sector entities. Therefore, this report identifies and recommends the following key areas for intervention by the manufacturers and the government:

6.1 RECOMMENDATIONS FOR CHARGING SERVICE

Integration of charging infrastructure with renewable generation offers charging to vehicle owners at an affordable price, the integration of charging stations with renewable sources of generation, such as solar PV or wind power, would be desirable from both an economic and environmental point of view. Charging stations, however, would need large solar PV arrays to provide sufficient electricity which, in turn, would require vast acreage for their installation. Such vacant space is seldom available in urban areas where EV chargers would be most needed, and land prices in such locations would make them unviable anyway. Instead, renewable generation could be installed at a considerable distance from charging stations, even outside city limits, where sufficient inexpensive or barren land could be available, and the energy produced wheeled to the charging stations utilizing the electricity utilities' transmission lines.

6.2 RECOMMENDATIONS FOR MANUFACTURERS AND PUBLIC SECTOR ENTITIES

1. Establishing Vehicle/Parts Testing and Characterization Facilities:
Grading the quality of batteries and motors is not possible without suitable hi-tech equipment. For small to medium industries, there are no publicly available laboratory facilities currently in Pakistan that could independently verify the quality or performance of EV/EVSE parts, a prerequisite of any product certification process. Quality certification of EV-specific parts, especially batteries and motors, is therefore presently not possible locally, due to which lower quality parts could easily proliferate in the industry, compromising the safety and performance of electric vehicles or charging infrastructure in the country. Under such circumstances, an accredited EV/EVSE testing facility needs to be established on a priority basis that can ensure product quality and compliance with standards.

2. Human Resource Development (HRD):
EVs have a significantly different powertrain compared with ICE-based vehicles. While there is sufficient availability of skilled engineers and technicians in Pakistan to design, develop, manufacture, and provide after-sales services for ICE-based vehicles, similar EV-related skill sets, being a comparatively new technology, are relatively scarce in the country. To nurture the nascent EV ecosystem in the country, there is a need to equip a sizeable work force with various EV-specific skills and knowledge. For this purpose, policies could identify and guide the quick development of relevant training programs and HRD programs directed at automobile assemblers, parts manufacturers, vendors, and service professionals.

3. Developing Ancillary Industry:
Globally, during the next ten years, a major shift from ICE vehicles to EVs is expected to take place. Considering Pakistan currently has more than 400 auto parts vendors, a serious effort to transition the vendor industry towards catering for EV manufacturing needs to be planned by the government and carried out in collaboration with the private sector. Currently, the quality of key EV components available locally—such as motors, motor control units and other electronics—does not meet the efficiency and quality requirements of EVs. Additionally, parts related to internet-of-things (IoT) features, where the main intellectual property (IP) is in developing software to operate a given hardware platform, are not available generally. Pure software startups are numerous in Pakistan, but IoT startups are not considered a popular investment option. While software startups in Pakistan are becoming increasingly attractive for venture capital funds, IoT startups are still largely not favored. A significant reason for this is the lengthy, laborious, and heavily regulated manufacturing licensing process, due to which few companies venture into IoT setups. Proper government facilitation and incentivization of the local software industry, including the EV IoT segment, could help indigenize this important element of future electric vehicles (potentially accounting for a third of total vehicle

4. EV Waste Recycling / Disposal Infrastructure:
As mentioned, access to many raw materials and rare used in EVs is already limited globally. To better manage the supply chain of rare earths and raw materials, it is crucial that an effective EV-related waste recycling industry be established in parallel. Once the batteries and many other components have completed their useful lives, they can be recycled to extract rare earth metals and key raw materials to be further processed and used in further industrial processes. For this purpose, the GoP needs to develop a policy support and regulatory regime to develop and support the EV recycling ecosystem.

5. Gender Equality and Social Inclusion (GESI):
There are almost negligible number of drivers in the two- and three-wheeler segments in Pakistan. These two vehicular categories are an import mode of commute for the lower- and middle-income segments of the population. Reversing these trends require intervention by the public and private sector.

* Recommendations for Public Sector Entities for Ensuring GESI:

- To promote GESI in the two- and three-wheeler segments, the government needs to introduce subsidized financing schemes to offer two- and three-wheelers to women at affordable rates.

- On some key roads/highways in the country, the government can dedicate 'women only' lane for female two- and three-wheeler drivers. This will make female drivers less susceptible to road-side accidents.

- The government can commence educational campaigns aimed at dispelling stereotypes and encouraging more women to consider riding two-wheelers. These campaigns could highlight the benefits of two-wheeler transportation, such as affordability, convenience, and reduced commute times.

- Training programs can be established that are specifically tailored to women riders, providing them with the skills and confidence needed to ride safely. These programs could include both basic riding skills and advanced safety training.

* Recommendations for Public Sector Entities for Ensuring GESI:

- The electric scooty in contrast to the typical electric two-wheeler in Pakistan offers many advantages for prospective women riders. First of it allows convenient handling of the vehicle which makes it less prone to accidents. Secondly, the unique design of the vehicle allows women with traditional eastern dresses to drive them with convenience. Finally, the low upfront purchase price and reduced operational expense in contrast makes these vehicles an attractive choice for prospective women drivers. To this end, the manufacturers need to focus on development of such vehicles to promote GESI.

ANNEXURES

ANNEX1A: TOTAL REGISTERED TWO- AND THREE-WHEELERS IN PAKISTAN, ANNUAL SALES NUMBERS, AND PERCENTAGE CHANGE IN ANNUAL SALES

A	B	C	D	E	F	G
YEAR	2-WHEELERS (CUMULATIVE)	2-WHEELERS ANNUAL SALE (NON-CUMULATIVE)	ANNUAL PERCENTAGE CHANGE IN 2-WHEELER SALES NUMBERS	3-WHEELERS (CUMULATIVE)	3-WHEELERS ANNUAL SALE (NON-CUMULATIVE)	ANNUAL PERCENTAGE CHANGE IN 3-WHEELER SALES NUMBERS
2011	5,781,953	-	-	266,390	-	-
2012	7,500,182	1,718,229	-	323,189	56,799	-
2013	9,169,528	1,669,346	-2.8%	380,579	57,390	1.04%
2014	11,006,421	1,836,893	10.0%	466,185	85,606	49.17%
2015	13,081,400	2,074,979	13.0%	559,114	92,929	8.55%
2016	15,223,925	2,142,525	3.3%	670,507	111,393	19.87%
2017	17,507,747	2,283,822	6.6%	761,420	90,913	-18.39%
2018	19,783,957	2,276,210	-0.3%	841,445	80,025	-11.98%
2019	22,001,277	2,217,320	-2.6%	919,020	77,575	-3.06%
2020	23,407,865	1,406,588	-36.6%	951,425	32,405	-58.23%
2021	25,119,891	1,712,026	21.7%	980,500	29,075	-10.28%
2022	26,884,786	1,764,895	3.1%	1,001,860	21,360	-26.53%
		Average (%)	5.2%		Average (%)	1%

ANNEX 1B: PROJECTED ELECTRIC TWO-WHEELER GROWTH TRENDS

A	B	C	D	E	F
YEAR	PROJECTED NEW ANNUAL SALE OF 2-WHEELERS	CUMULATIVE 2-WHEELERS ON ROADS	% SHARE OF ELECTRIC 2-WHEELERS IN ANNUAL SALES	NEW ANNUAL ELECTRIC 2-WHEELER SALES	CUMULATIVE ELECTRIC 2-WHEELERS
2023	1,855,879	28,740,665	1%	18,559	18,559
2024	1,951,554	30,692,220	7%	140,512	159,071
2025	2,052,161	32,744,381	14%	295,511	454,582
2026	2,157,955	34,902,336	22%	466,118	920,700
2027	2,269,203	37,171,539	29%	653,530	1,574,231
2028	2,386,185	39,557,725	36%	859,027	2,433,257
2029	2,509,199	42,066,924	43%	1,083,974	3,517,231
2030	2,638,554	44,705,477	50%	1,319,277	4,836,508
2031	2,774,577	47,480,055	54%	1,498,272	6,334,780
2032	2,917,613	50,397,668	58%	1,692,216	8,026,996
2033	3,068,023	53,465,691	62%	1,902,174	9,929,170
2034	3,226,187	56,691,878	66%	2,129,283	12,058,454
2035	3,392,504	60,084,382	70%	2,374,753	14,433,207
2036	3,567,396	63,651,778	74%	2,639,873	17,073,079
2037	3,751,303	67,403,081	78%	2,926,017	19,999,096
2038	3,944,692	71,347,773	82%	3,234,647	23,233,743
2039	4,148,050	75,495,823	86%	3,567,323	26,801,066
2040	4,361,891	79,857,714	90%	3,925,702	30,726,768

ANNEX 1C: PROJECTED ELECTRIC THREE-WHEELER GROWTH TRENDS

YEAR	PROJECTED NEW ANNUAL SALES OF 3-WHEELERS	CUMULATIVE 3-WHEELERS ON ROADS	% SHARE OF ELECTRIC 3-WHEELERS IN ANNUAL SALES	NEW ANNUAL ELECTRIC 3-WHEELER SALES	CUMULATIVE ELECTRIC 3-WHEELERS
2023	21,559	1,023,419	1%	216	216
2024	21,760	1,045,180	7%	1,567	1,782
2025	21,963	1,067,143	14%	3,163	4,945
2026	22,168	1,089,311	22%	4,788	9,733
2027	22,375	1,111,686	29%	6,444	16,177
2028	22,584	1,134,270	36%	8,130	24,307
2029	22,794	1,157,064	43%	9,847	34,155
2030	23,007	1,180,071	50%	11,503	45,658
2031	23,222	1,203,292	54%	12,540	58,198
2032	23,438	1,226,731	58%	13,594	71,792
2033	23,657	1,250,387	62%	14,667	86,459
2034	23,877	1,274,265	66%	15,759	102,218
2035	24,100	1,298,365	70%	16,870	119,088
2036	24,325	1,322,690	74%	18,000	137,089
2037	24,552	1,347,242	78%	19,150	156,239
2038	24,781	1,372,023	82%	20,320	176,559
2039	25,012	1,397,035	86%	21,510	198,070
2040	25,245	1,422,280	90%	22,721	220,791

ANNEX 1D: FUEL SAVINGS AND GHG MITIGATION POTENTIAL UNDER EV ADOPTION

	SCENARIO-A: EV ADOPTION AS PER POLICY TARGETS		SCENARIO-B: 0% EV ADOPTION	
YEAR	EMISSION FROM 3-WHEELERS (TCO2E)	FUEL IMPORT REQUIRED FOR 3-WHEELERS (million USD)	EMISSION FROM 3-WHEELERS (TCO2E)	FUEL IMPORT REQUIRED FOR 3-WHEELERS (million USD)
2023	4,174,671	908	4,175,550	908
2024	4,257,061	926	4,264,333	928
2025	4,333,767	943	4,353,943	947
2026	4,404,677	958	4,444,389	967
2027	4,469,675	972	4,535,679	987
2028	4,528,646	985	4,627,820	1,007
2029	4,581,470	997	4,720,821	1,027
2030	4,628,404	1,007	4,814,689	1,047
2031	4,671,987	1,016	4,909,433	1,068
2032	4,712,150	1,025	5,005,061	1,089
2033	4,748,828	1,033	5,101,580	1,110
2034	4,781,950	1,040	5,199,000	1,131
2035	4,811,449	1,047	5,297,329	1,152
2036	4,837,253	1,052	5,396,575	1,174
2037	4,859,291	1,057	5,496,746	1,196
2038	4,877,490	1,061	5,597,852	1,218
2039	4,891,776	1,064	5,699,901	1,240
2040	4,902,077	1,066	5,802,902	1,262

ANNEX 1E: INDIRECT INCENTIVES FROM THE AIDEP 2021-26 FOR ALL VEHICLE CATEGORIES

INDIRECT INCENTIVES FOR OFFERED BY THE AIDEP 21-26

INCENTIVE TYPE	DESCRIPTION
Additional customs duty (ACD)	0% on CKD manufacturing
CD and ACD on import of plant and machinery	0%
CD and ACD on import of chargers	CD 1%, ACD 0%
Federal excise duty (on imported and locally manufactured EVs)	Exempted
Annual tax	Provincial motor vehicle registration authorities to consider fully waiving annual renewal fee for all EV types
Power tariff	Power Division, Ministry of Energy, to provide special incentivized power tariff to charging stations for EVs
Toll charges	NHA/Ministry of Communications to consider partial (50%) exemption of EVs from toll taxes
Insurance	Bulk insurance at concessional rates for commercial fleets of electric vehicles
Registration of vehicles	Provincial motor vehicle registration authorities to consider exemption of EVs from registration fees. License number plates of EVs may have distinct color/design as per directive of registration authorities. License plates to be provided unique identification numbers by provincial/ICT registration authorities
Standardization	Standards for all vehicle segments that are in line with WP-29 regulations need to be developed for all vehicle segments. The AIDEC or National Standards Committee of PSQCA to analyze and recommend adoption of UNR 136 for vehicle safety, IEC60335-2-29 for household chargers and EEC 134 for maximum speed for two-wheelers and UNR 100 for four-Wheelers (or Chinese OEM standards) in order to ensure safety of customers and safeguard against substandard products

ANNEX 1F: LIST OF INTERVIEWEES

LIST OF INTERVIEWEES

SR.#	NAME	COMPANY	TYPE	WEBSITE/LINKEDIN
1	Abdul Ghafoor	NueWat	Chargers/Batteries	
2	Abdul Samad	Power Pack	Batteries	https://powerpack.com.pk/
3	Ahmad Najeeb	Albario Engineering (Pvt) Ltd.	Chargers	https://aepl.com.pk/
4	Ali Hameed	Sazgar Engineering works Ltd	3-Wheelers	https://sazgarautos.com/
5	Brig. (R) Farhan Ahmad	Buraq E Wheel	Motors	https://www.buraaqstore.com/
6	Dr. Waseem Akram	Transport Department Punjab	Government	https://transport.punjab.gov.pk/
7	Faiq Ahmad	Punjab Transport Company	Government	https://ptc.punjab.gov.pk/
8	Hassan Iqbal Khan	ZYP Technologies	2-Wheelers	https://www.zyptechnologies.com/
9	Hassan Mian	YES Electromotive	3-Wheelers	https://yeselectromotive.com/
10	Hira Ashraf	Punjab Energy Efficiency & Conservation Agency	Government	https://peeca.punjab.gov.pk/
11	Mansoor Lashari	BarqBox	Batteries	https://barqbox.com/
12	Mohiyudin	Teleport	2-Wheelers	https://www.linkedin.com/company/teleportev/
13	Rehan Aslam	Zoxcell	Batteries	https://zoxcell.com/
14	Saad Farrukh	evee Electric	2-Wheelers	https://evee.pk/
15	Shah Alam	PLUM Qingqi Motors	2&3-Wheelers	https://qingqi.com.pk/
16	Tanzeel Ahmed	Indus Electric	Retro-fit EV Kits	https://www.induselectric.com.pk/
17	Usman Sheikh	Jolta Electric	2-Wheelers	https://www.joltaelectric.com/

ANNEX 2A: LIST OF ELECTRIC TWO-WHEELER MANUFACTURERS APPROVED BY EDB

2-WHEELER EV MANUFACTURERS APPROVED BY EDB

S. NO.	NAME OF OEM / ADDRESS	VARIANT/ MODEL
01	**M/s Jolta Electric (Pvt) Ltd., Lahore.** **Address:** Plot No. 745-746-747, Sunder Industrial Estate, Gate No. 03, Near Raiwind Lahore, Lahore **Tel:** 0300-8557824/ 0300-4276165 **E-mail:** info@joltaelectric.com	Jolta JE-50D (Electric Motorcycle) Jolta JE-50L (Electric Motorcycle) Jolta JE-70D (Electric Motorcycle) Jolta JE-70L (Electric Motorcycle) Jolta JE-100L (Electric Motorcycle) Jolta JE-125L (Electric Motorcycle)
02	**M/s Plum Qingqi Motors Ltd., Lahore.** **Address:** 43-Km, Multan Road, Mange Mandy, Lahore, **Tel:** 042-7211506, Fax: 042-5383804	Qingqi QM-70 (Electric Motorcycle)
03	**M/s La He Trading International (Pvt) Ltd.** **Address:** Plot No. 298, Phase-II, M3 Industrial City (FIEDMC), Faisalabad **Tel:** 0314-5632061,	Yuan Jun 2-Wheeler (Electric Motorcycle) Yuan Jun Azadi 2-Wheeler (Electric Motorcycle)
04	**M/s Elite Auto Industry (Pvt) Ltd., Karachi.** **Address:** Plot No. 254 & 255, Sector No. 24, Korangi Industrial Area, Karachi **Tel:** 0300-2000645	Elite Sawari EAI-2KW (Electric Motorcycle) Elite Sawari EAI-3KW (Electric Motorcycle)
05	**M/s Treet Holding Ltd., Lahore.** **Address:** 72-B, Industrial Area, Kot Lakhpat, Lahore, **Tel:** 042–358 308 81 Fax: 042–352 156 47	Treet Voltaic TV-70 Electric Motorcycle
06	**M/s Nova Mobility (Pvt) Ltd., Karachi.** **Address:** Ground Floor, G & T Tower, # 18 Beaumont Road, Civil Lines-10, Karachi **Tel:** 021-35659585-7 Fax: 021-35659549	EcoDost 2-Wheeler ED-70 Electric Motorcycle 1500 Watt
07	**M/s Waleed Trading Company, Faisalabad.** **Address:** P-20, Ground Floor, Bilal Road, Civil Lines, Faisalabad. **E-mail:** waleedtradingcoofficial@gmail.com	Road King RKEV-70 Electric Motorcycle
08	**M/s MS Automobiles (Pvt) Ltd., Sahiwal.** **Address:** 1-A, Industrial Estate, Sahiwal, **Tel:** 040-4554083 Fax: 040-4554082	MS Jaguar Electric Motorcycle MS Jaguar Electric Scooter
09	**M/s Pakzone Electric Motors (Pvt) Ltd., Lahore.**	PE-70L (Electric Motorcycle) PE-70D (Electric Motorcycle) PE-125L (Electric Motorcycle)

10	**M/s United Auto Industries (Pvt) Ltd., Lahore.** **Address:** 75 E, Moulana Shoukat Ali Road, Johar Town, Lahore **Tel:** 042-3521881-3	United Revolt Electric Motorcycle United Spark Electric Motorcycle United Bullet Electric Motorcycle
11	**M/s Memon Motor (Pvt) Ltd., Hyderabad.** **Address:** Plot No. G-4, Hash Colony, Pop. Zeal Park, Site, Hyderabad, **Tel:** 022-3882284 Fax:022-3880502	Super Star SSE-MDW Electric Motorcycle Super Star SSE-MMW Electric Motorcycle
12	**M/s Vitality Electric Vehicles, Karachi.** **Address:** GPC-13, Rojhan Street, Block-5, Clifton, Karachi **Tel.** 0322-2448387	Bolt Electric Motorcycle Retro Electric Motorcycle Velocity Electric Motorcycle
13	**M/s Inner Z Automotive (Pvt) Ltd., Islamabad.** **Address:** 3rd Floor, Safdar Mansion, 16-D, Near Tabbaq Hotel, Blue Area, Islamabad. **Tel:** 051-8840517	Inner Z Electric Motorcycle
14	**M/s Crown Motor Company (Pvt) Ltd., Sadiqabad.** **Address:** Ahmed Pur Lama Road, Near Bypass, Mouza Wahid Bakhsh Mahar, Sadiqabad, **Tel:** 068-5800653, 5803053 Fax: 068-5800764	Crown Electric Motorcycle Crown Electric Scooty
15	**M/s Dharala Auto Industry, Bahawalpur.**	Sutlej EDA Electric Motorcycle
16	**M/s E-Turbo Motors (Pvt) Ltd., Hyderabad** **Address:** A-17/C, Shalimar Compound, SITE area, Karachi. **Tel.** 021-32579944 **E-mail:** info@eturbomotors.com	E Turbo ET-Electric Motorcycle 1500 Watt E Turbo ET-Electric Motorcycle 2000 Watt
17	**M/s Ride Star Automobiles, Okara** **Address:** Al-Noor Plaza Street, New Lalazar, Church Road, Okara **Tel:** 0307-2637770 **E-mail:** ridestarautomobiles@gmail.com	Ride Star RSEV-70 Electric Motorcycle Ride Star RSEV-100 Electric Motorcycle Ride Star RSEV-125 Electric Motorcycle
18	**M/s Rehman Auto Industry, Bahawalpur** **Address:** 8-KM, Hasil Pur Road, Bahawalpur Tel: 062-2281472 Fax: 062-2281472	Rohi RIEV-70 Electric Motorcycle
19	**M/s Eiffel Industries Ltd., Kasur** **Address:** Shed A-2, B-33/C, S.I.T.E., Karachi, **Tel:** 021-32562223	Road Prince RPEV-70 Electric Motorcycle Road Prince RPEV-Electric Scooty
20	**M/s Pak Star Automobile (Pvt) Ltd., Sheikhupura** **Address:** 19-KM, Multan Road Behind High-noon Laboratory, Lahore **Tel:** 042-7511778 Fax: 042-7511615	Metro T9-Electric Scooter
21	**M/s HH Trading & Engineering Works, Hyderabad** **Address:** A-108A, Indus Hill Near Custom Office, SITE, Hyderabad **Tel.** 0307-3080702, 0315- 3080702	E-Hawk EH-Electric Motorcycle 1500 Watt
22	**M/s AlhMmdAli EPC Co. (Pvt) Ltd., Rajanpur** **Address:** China Minitown Electric Vehicle Town - Kotla Naseer Chowk, Rajanpur	AlhMmdAli 2-Wheeler Electric Motorcycle (Electric Vehicle)

23	**M/s Siwa Industries (Pvt) Ltd Lahore** **Address**: Plot No. 6, Opp. Street to Nizami Engineering, Bund Road, Bhamma, Shad Bagh, Lahore **Tel**: 042-7604970 Fax: 042-7285361	Siwa SWE-Electric Motorcycle Siwa SWE Electric Scooty
24	**M/s Fusion Engineering (Pvt) Ltd., Lahore** **Address**: 19-KM, Baghdadi Lane, Multan Road, Lahore	Road Star RSEV-Electric Scooty
25	**M/s Roamer Technologies (Pvt) Ltd., Islamabad** **Address**: Plot No. 60-J, Street-7, I-10/3, Islamabad **Tel**: 0345-5255373, **E-mail**: ali.moeen@roamer.pk	ezBike Electron Electric Scooty 2000 Watt
26	**M/s Sara Automobile Industries (SMC-Pvt) Ltd., Karachi** **Address**: 820, Secretariat View, AM 20, Al-Karam Building, Frere Road, Saddar, Karachi, **Tel**: 021-2736873 Fax: 021-2742124	Union Star US-Electric Motorcycle 1500 Watt Union Star US-Electric Scooty 2000 Watt
27	**M/s Prime Star Automobiles (Pvt) Ltd., Lahore** **Address**: 45-K.M. Multan Road, Nathay Khalsa Stop, Manga mandi, Lahore **Tel:** 049-4540540, 0301-8467168	Prime Star PSEVS Electric Scooty Prime Star PSEV Electric Motorcycle
28	**M/s AIM Motors (Pvt) Ltd., Karachi** **Address**: WAK House, 3rd Floor, Building No. 25-C, Al-Murtaza Commercial Lane 4, DHA Phase VIII, Saddar Town, Karachi **Tel:** 0331-3479798, **E-mail:** info@aim-ge.com	Nayel 3.8E (72V/ 27AH & 2KW) Electric Motorcycle
29	**M/s New Asia Vehicles (Pvt) Ltd., Lahore** **Address**: 18-KM, Sheikhupura Road, Lahore, **Tel**: 042-37168891 Fax: - 042-37168891	New Asia NEV-Electric Scooty
30	**M/s Atlas Honda Ltd.** **Address**: 1-Mcleod Road, Lahore-54000, **Tel**: 042-7225015-17, 72338515-17	Honda Benly e: EV Scooter

ANNEX 2B: LIST OF ELECTRIC THREE-WHEELER MANUFACTURERS APPROVED BY EDB

3-WHEELER EV MANUFACTURERS APPROVED BY EDB

S. NO.	NAME OF OEM	VARIANT/ MODEL
01	**M/s Sazgar Engineering Works Ltd., Lahore.** **Address:** 18 Km Raiwind Road, Lahore, **Tel:** 042-5330300-3 Fax: 5330329	Sazgar Mini Cab Electric Auto Rickshaw Sazgar Mini Cab Swappable Electric Auto Rickshaw Sazgar Tempo 3-Wheeler Electric Loader
02	**M/s Nova Mobility (Pvt) Ltd., Karachi.** **Address:** Ground Floor, G & T Tower, # 18 Beaumont Road, Civil Lines-10, Karachi **Tel.** 021-35659585-7 Fax: 021-35659549	EcoDost 3-Wheeler Electric Loader
03	**M/s Eiffel Industries Ltd., Kasur** **Address:** Shed A-2, B-33/C, S.I.T.E., Karachi, **Tel:** 021-32562223	Road Prince RPEV-Electric Loader
04	**M/s AlhMmdAli EPC Co. (Pvt) Ltd., Rajanpur** **Address:** China Minitown Electric Vehicle Town - Kotla Naseer Chowk, Rajanpur	AlhMmdAli 3-Wheeler Electric Loader (Electric Vehicle)
05	**M/s New Asia Automobile (Pvt) Ltd., Lahore** **Address:** Manzoor Park, Zahoor Road, Near Saggian Bridge, Lahore **Tel:** 042-7147856-57 Fax: 042-7146565	New Asia NER-EV Electric Auto Rickshaw New Asia NECL-EV Electric Cargo Loader

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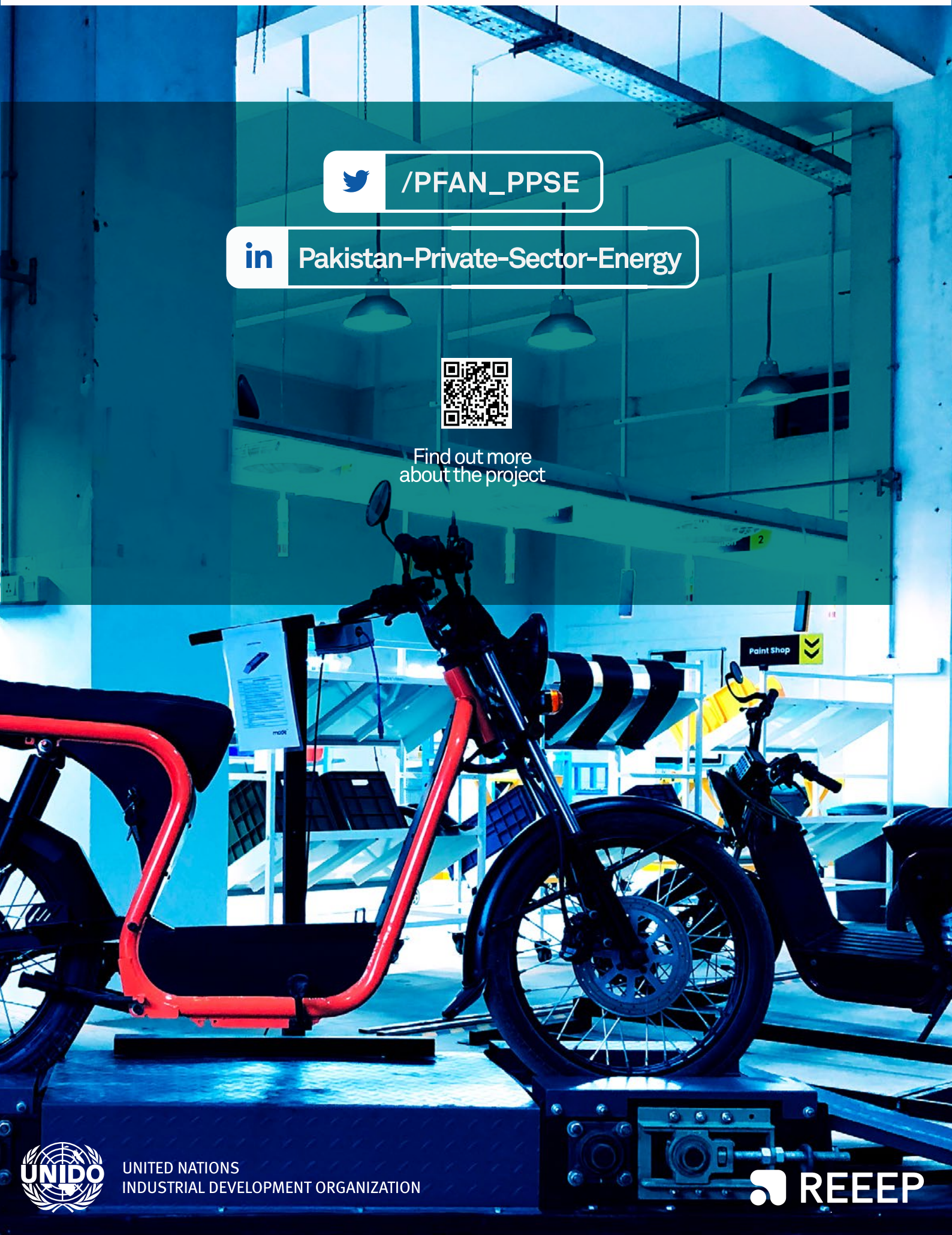

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