Market Preparedness and Socio-Economic Prospects of Electric Vehicles in Pakistan

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MARKET PREPAREDNESS AND SOCIO-ECONOMIC PROSPECTS OF ELECTRIC VEHICLES IN PAKISTAN

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ABBREVIATIONS

Abbreviation	Description	Abbreviation	Description
CAGR	Compound Annual Growth Rate	**Mtoe**	Million Ton of Oil Equivalent
IEA	International Energy Agency	**BEVs**	Battery Electric Vehicles
PHEVs	Plug-In Hybrid Electric Vehicles	**EVs**	Electric vehicles
CEM	Clean Energy Ministerial	**OEM**	Original Equipment Manufacturer
EVI	Electric Vehicles Initiative	**GEF**	Global Environment Fund
PAMA	Pakistan Automotive Manufacturers Association	**LEAP**	Low-Emission Analysis Platform
HDIP	Hydrocarbon Development Institute of Pakistan	**NREL**	National Renewable Energy Laboratory
NEPRA	National Electric Power Regulatory Authority	**NDC**	Nationally Determined Contributions
ENE	Energy Transition Scenario.	**NEVP**	National Electric Vehicle Policy
MoIP	Ministry of Industries and Production	**MoCC**	Ministry of Climate Change
SBP	State Bank of Pakistan.	**CKD**	Completely Knocked Down
CBU	Completely Built Unit	**CD**	Customs Duty
GBGs	Green Banking Guidelines	**IMF**	International Monetary Fund
VAT	Value added Tax	**PSO**	Pakistan State Oil
SEZs	Special Economic Zones	**TCO**	Total Cost of Ownership
BAU	Business as Usual	**EPS**	Electric Vehicle Policy Scenario
SGS	Slow Growth Scenario		

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EXECUTIVE SUMMARY

Increase in demand for electric vehicles observed due to the high cost of imported fossil fuels, trade deficit, and environmental impacts of fuel combustion.

In 2020, the transport sector of Pakistan consumed approximately 15.7 Mtoe of energy (30% of the country's total consumption). This energy was, however, entirely based on fossil fuels, a large quantity (43%) of which is imported. This has resulted in multi-dimensional challenges ranging from trade deficit to deteriorating environment profile.

From July-April of the FY-2022, oil imports of Pakistan increased by 95.9% to approximately $17 billion. This increase has been attributed to both the increase in demand and the increase in value (increase of 121.5%), thus triggering the country's trade deficit. As of January 2022, the trade deficit of Pakistan surged to $24.79 billion in the first half due to a 63% increase in a year-on-year basis. On the second front, the transport sector was the 2nd largest CO_2 emitter among demand sectors, emitting 51 Mt of emissions in 2021. It is further contributing to constantly declining air quality standards. Driven mainly by vehicular and industrial emissions, Pakistan's urban environment was ranked as the fifth most polluted in the world.

These challenges have, therefore, spurred an extensive debate in Pakistan for transitioning toward Electric vehicles as it may provide opportunities to both economic and environmental threats posed by fossil fuel-based vehicles.

Growth in Electric Vehicle Market still lags far behind the targets prescribed under Pakistan's Electric Vehicle Policy

Pakistan's National Electric Vehicle Policy 2019 put forward by the Ministry of Climate Change, aims to achieve a 30% share in sales for electric cars and trucks and 50% for two-wheelers and buses by 2030. By 2040, the target for each category is ambitiously increased to 90%. Given the 2020 stock of electric vehicles in Pakistan, this requires an average Compound Annual Growth Rate (CAGR) of 124% till 2030.

As per these targets, Pakistan would require the sale of 60,000 electric cars and 900,000 electric bikes by 2030. However, EV growth is currently on a very slow track and lags behind the required numbers. As per the Economic Survey of Pakistan, approximately 300 electric vehicles were imported in 2021. , and the total number of electric vehicles plying on the roads is only 720.

Scope and Methodology

To derive a policy and socio-economic analysis, we have conducted an extensive desk review, Energy-Economic-Environmental modeling through Low Emission Analysis Platform (LEAP), Public-Private Dialogue on "Market Preparedness and Socio-Economic Prospects of electric vehicles in Pakistan" and Key Informant Interviews.

The key objective of the report revolves around the critical analysis of regulatory and policy support for EVs and benchmarking it with global best practices, understanding the socio-economic benefits provided through compliance with EV policy targets, understanding the market readiness of EVs in Pakistan, and recommending the way forward for a rapid off-take.

For ENE-ECO-ENV analysis, four different scenarios have been modelled, i.e. i) Business-as-Usual (BAU), ii) EV Policy Scenario, iii) Slow Growth Scenario, and iv) Energy Transition Scenario. These scenarios operate under different assumptions and model drives to provide sectoral and sub-sectoral impacts each policy and intervention can have. For market readiness, the assessment framework mainly revolves around the current and upcoming commitments of local/international companies planning to develop EV market in Pakistan (for both vehicles and infrastructure), the current cost of EV ownership in Pakistan, and the regulatory support that is provided for EVs.

Energy-Economic-Environmental Prospects of EVs in Pakistan [Model Outputs]

Reduced Energy Demand and Fuel Substitution

Under BAU, the energy demand from the transport sector is expected to increase from 15 Mtoe in 2020 to 20 Mtoe and 27 Mtoe by 2030 and 2040 respectively. This demand would remain highly dominated by fossil fuels with gasoline contributing to the largest share of 52.76 per cent followed by 44.2% from diesel. However, through the penetration of electric vehicles in the transport sector, the energy profile could depict the following change:

- Depending on the scenario, transport demand by 2030 could vary between 17 Mtoe (low-end) and 20 Mtoe (high-end). By 2040, these could further vary between 27 Mtoe and 19.8 Mtoe.
- Complying with the policy targets of NEVP 2019, Pakistan can cumulatively save around 2 Mtoe of energy by 2030 and 5 Mtoe of energy by 2040 driven by the low energy requirements of electric vehicles. By 2030 & 2040, the overall demand of the transport sector in EV policy scenario would be around 0.3 Mtoe and 0.7 Mtoe less than the BAU scenario.

- In a slow-growth scenario (where EVs will achieve a share of 15% sales by 2030), the cumulative energy savings by 2030 and 2040 are limited to 0.7 Mtoe and 3.3 Mtoe respectively.
- The energy transition scenario (driven by improvements in fuel efficiency and a shift to mass-transit and railways, along with EVs) depicts a much larger energy-saving potential. Under this scenario, the cumulative energy savings till 2030 and 2040 are 12.5 Mtoe and 58.7 Mtoe respectively. On annual basis, the total annual demand of the transport sector by 2030 and 2040 would be 2.5 Mtoe and 6.3 Mtoe lower than the BAU scenario.

Along with energy demand reduction, the model results also analyze the increased requirements of electricity in the transport sector. To ensure compliance with the EV policy targets, Pakistan would have to manage an additional 3351 GWh and 7331 GWh of electricity by 2030 and 2040 respectively. In Energy transition scenario, this requirement is lowered to 2818 GWh and 5135 GWh by 2030 and 2040, driven by low travelling requirements.

With the penetration of EVs, the demand of fossil fuels (mainly gasoline and diesel) will also drop. Through compliance with EV policy targets, the annual consumption of Gasoline and Diesel by 2030 would be 0.32 and 0.18 Mtoe lower than the BAU scenario. This also indicates a cumulative diesel savings of around 1 Mtoe by 2030 and 4 Mtoe by 2040. For gasoline, these cumulative savings are 1.6 Mtoe and 7 Mtoe by 2030 and 2040 respectively. In the ETS, cumulative gasoline savings are around 9.4 Mtoe by 2030 and 42 Mtoe by 2040. For diesel, these savings are 5.5 Mtoe and 25.6 Mtoe by 2030 and 2040 respectively.

Economic benefits through lower running cost and total cost of ownership

The cost modelled through LEAP in this study is mainly the running cost associated with different categories of vehicles. Multiple economic benefits can be achieved through the penetration of electric vehicles as highlighted below:

- In 2022, the cumulative running cost of all vehicles combined was around $16.1 billion. Under BAU, this value is expected to reach $21 billion by 2030 and $29 billion by 2040. Passenger transport contributes to the major share of around 88.8%.
- Under the EPS, running cost in 2030 and 2040 would increase to $21.5 billion and $28.6 billion respectively. As compared to BAU, this represents a decrease of $0.2 billion and $0.5 billion in respective years. It indicates that through penetration of EVs as per the policy, there is a potential to save approximately $1200 million by 2030 and $4300 million by 2040.
- Since cost savings are an index of EV penetration, the highest percentage of cost savings is achieved in the energy transition scenario. By 2030 and 2040, the cost in ENE has increased to $19.7 billion and $23.9 billion respectively. This is significantly lower than the corresponding values in $21.7 billion and $29.1 billion in BAU for the respective years.

While the above-mentioned statistics highlight the long-terms socio-economic benefits of EVs, the total cost of ownership despite a high capital cost is lower than the counterpart ICE vehicles. Based on the key current prices (September 2021), the economic benefits offered by EVs through TCO are summarized below:

- The capital cost of Electric 2-wheelers is 41% higher than the ICE counterpart, however, the TCO for a 5-year period of Electric 2-wheeler is almost 49% less than the ICE counterpart.
- The capital cost of Electric 3-wheeler is almost 50% higher than the ICE cunterpart, however, the TCO for Electric 3-Wheeler is almost 52% less than the ICE counterpart.
- The capital cost of electric car is almost 10% higher than the ICE counterpart, however, the TCO for electric car is almost 7% less than the ICE counterpart.

Environmental Prospects of EVs in Pakistan

Both the energy and environmental sectors in Pakistan are strongly linked with each other. Any intervention impacting the energy growth has an equal or greater impact on the environmental profile. Currently, around 59 Mt of CO_2 is emitted through transportation in Pakistan. By 2030 & 2040 under BAU, this value is expected to reach around 77.5 Mt and 102.1 Mt respectively. This indicates an CAGR of 2.76%. The emission profile under different scenario indicates the following:

- In EPS, the emissions from the transport sector are 2.1 Mt and 4.9 Mt lower than the corresponding values in BAU scenario. This indicates that compliance with EV policy targets could lead to cumulative emission reductions of around 17 Mt by 2030.
- In energy transition scenario, the annual emissions by 2030 and 2040 would increase to 67.5 Mt and 75.8 Mt respectively. Cumulatively, this indicates the highest emission reduction potential of 139.6 Mt.

The statistics highlighted above for ENE-ECO-ENV perspectives describe a very strong socio-economic case for electric vehicles in Pakistan. However, this would require a strong policy & regulatory support that can ensure the development of infrastructure at an equally rapid pace.

Policy Inconsistency and Lack of ownership - a major challenge for EV off-take in Pakistan

With the launch of National Electric Vehicle Policy, an extensive debate has been initiated between the Ministry of Climate Change and the Ministry of Industries and Production where the latter has announced that any policy relevant to the automotive sector of Pakistan is the mandate of Industries ministry and its associated department such as Engineering Development Board (EDB). Although NEVP 2019 was approved by the federal cabinet, the regulatory support offered to electric vehicles and the associate infrastructure kept on changing under different taxation regimes. Few months later, , EDB has also put forward an EV policy for 2-3 wheelers and heavy transport. In 2021, Automotive Industry Development and Export Plan 2021-26 was put forward that also mentioned regulatory support to EVs.

Despite this policy and regulatory landscape, the taxation and regulatory support for EVs keep on changing and many incentives prescribed under the EV policy were not implemented until the mini budget 2021. Driven by the global economic challenge due to COVID-19 impacts and Ukraine-Russia crisis leading to high trade deficit in Pakistan, the regulatory duties for imported EVs were also removed in mid-2022. These constantly changing market values have created an unfriendly environment for the private sector and international companies to mobilize the off take of EVs.

Industry preparedness improving but still off-track to achieve required levels of growth

Despite the socio-economic prospects offered by electric vehicles, the industry remains unprepared to mobilize its rapid off-take. This is mainly due to lack of supporting infrastructure, imported technology, high capital cost of both vehicle and equipment, lack of awareness among customers, lack of standard protocols developed in the country, and an unfriendly regulatory environment. While the past two years have seen some initiatives taken by local as well as international companies, Pakistan is yet to start a large-scale manufacturing facility for production of any electric vehicle category.

For four-wheelers, the major players in Pakistan are MG, Audi, and Zia Electromotive which have committed to starting the business of low-cost electric cars. For LTV and HTV, Pakistan still does not have a complete electricity operated fleet, however, some PHEVs are operating on E-mobility. For this category, the key market players are Sapphire and VPL Pakistan Group of Companies. Unlike HTV, LTV, and electric cars, the market for 2-wheeles and 3-wheelers has shown some progress (including their battery packs). For three-wheelers, Sazgar Engineering Works Limited is the key player whereas for 2-wheelers, around 10 companies (Super star, Indus motors, Jolta Electric, Sunra, Iner-Z, Mega electric, Elite auto industries, and TP) are working.

Policies and interventions required to leverage momentum for EVs

While the progress is slow, eectric vehicles are a critical component of Pakistan's energy as well as climate actions. A stronger ambition will be required to bring it on-track with national goals.

In a short-term, this would initially require achieving the "Critical Mass Number" by converting the public sector fleet to electric. For engaging the private sector, the government needs to ensure consistency in policy targets and regulatory support that is being offered to the EVs. For this, the ownership of EV policy and the implementation framework to achieve the targets prescribed under it must be among the top priorities for this sector. To provide the ease of business to the private sector to register and install EV related infrastructure, the relevant entities must provide a single-window clearance system that can fast track the process. This would also enable the private sector through joint ventures with international companies for localization of technology. To further ensure a rapid growth in the initial stages, the provision of incentive schemes such as free registration, relaxation in customs duty and import levy, tax incentives for local manufacturing, reduced tolls on highways, lower power tariffs for charging infrastructure, provision of early bird incentives, bonds, and government backed loans will be much needed.

In medium to long-term, localization of technology (both vehicles and infrastructure i.e. chargers, batteries, IT systems, and other supporting equipment) needs to be the key focus of Pakistan's efforts in developing a strong EV market. The opportunity of declining capital cost of EVs and the consequent decline in trade deficit of Pakistan would not be harnessed unless the entire supply chain is operating within the country. Alongside, this would also require ensuring the quality of imported or locally produced EV through the provision of Unique Identification Numbers(UIN) to batteries as well as other EV components. To ensue inter-operate ability of EV components, the developers and OEMs must develop an inter operate ability framework, which can include standardization of battery packs, standard protocols between battery management systems, developing local testing facilities, and maintain a strict oversight on EVs that are converted from ICEs. On the consumer end, the socio-economic advantages of adopting EVs must be advocated through capacity building programmes driven by government in support from the public sector and CSOs. Capacity building of the ICE workforce is to be carried out with targeted skill developments to work in the EV industry.

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CHAPTER 1:

1. INTRODUCTION

1.1. Global Outlook of Transport Sector

Transport sector plays a very critical role in the global economy. It not only facilitates people in their mobility but also help in supply of goods across and within countries (Gnann *et al.*, 2018). By 2019, the global energy consumption from the transport sector was around 2980 Mtoe (International Energy Agency [IEA], 2019). This constitutes a share of around 30 per cent in global energy consumption. The major supply (91 per cent) of this demands comes from oil products, followed by natural gas (119 Mtoe), biofuels and waste (95 Mtoe), and electricity (around 36 Mtoe) (ibid). Right after the outbreak of COVID-19 pandemic, transport was among the most hard-hit sectors and its energy consumption fell below 2,500 Mtoe (International Energy Agency (IEA), 2021d). In 2021, the total energy demand increased by 4.6 per cent (International Energy Agency (IEA), 2021a), but the transport activity and its demand remained suppressed. The pandemic impact was not uniform across all the fuels, as the total consumption of fuels fell 14 per cent below their 2019 levels. Resultantly, the emissions from the transport sector also fell to a new low in the past few years. The global emissions from the transport sector fell from around 8.5 $GtCO_2$ equivalent in 2019 to slightly above 7 $GtCO_2$ equivalent in 2020. **Figure 1** presents the global energy consumption of transport sector and resulting emissions.

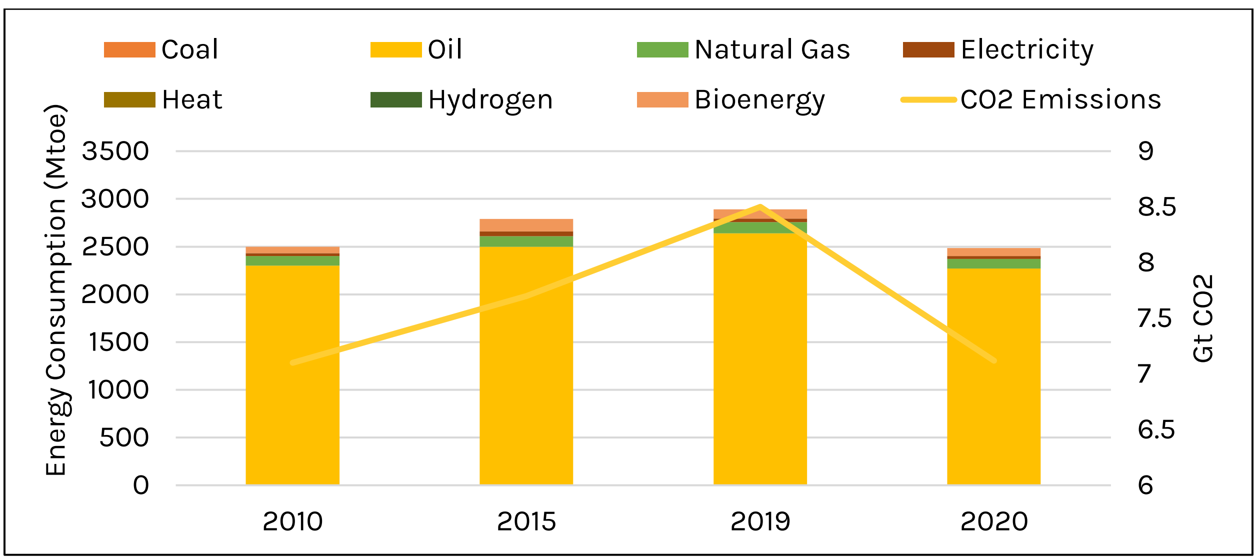


Figure 1: Global energy consumption and resulting emissions from the transport sector [Source: Figure designed by the authors through data obtained from the International Energy Agency (International Energy Agency (IEA), 2021d, 2021a, 2021b)]

Against a consumption share of around 30 per cent, transport sector accounts for almost 37 per cent of global emissions given a comparatively high use of fossil fuels (International Energy Agency (IEA), 2021c). Although it was highly affected by COVID, the emissions are expected to bounce very rapidly, if suitable measures are not taken in the post-COVID recovery period(Davis *et al.* 2022).

Key measures that have been globally adopted in the past decade include the use and blending of biofuels with gasoline and diesel, improving fuel efficiency, increased reliance on railways (for countries having rail infrastructure), and electrification of the transport sector through Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) (Björnsson, Karlsson and Sprei, 2018; Simsekoglu, 2018). The transition towards electric vehicles has been one of the most impactful strategies to decarbonize this sector (Patil and Kalkhambkar, 2020). Along with providing long-term economic benefits, it offers energy security, environmental benefits, electricity stability, and further as RE grid flexibility grows, it ensures an optimum utilization of variable renewable energy sources as well. Currently, for Electric Vehicles (EVs), a major challenge is its high capital investments but with advancement in battery storage technology, the cost difference is rapidly changing (Lander *et al.*, 2021). In 2020, electric vehicles consumed around 80 TWh of electricity which constitutes around 1 per cent of the global electricity consumption (International Energy Agency (IEA), 2020b). Only in 2020, around 50 Mt of CO_2 emissions were saved through EVs (ibid).

1.2. Global Statistics of Electric Vehicle Market

After a decade of rapid growth in the electric vehicle market across the world, there were around 10 million electric cars on the roads in 2021 (Zapmap, 2021). Despite the pandemic after which the sale of cars dropped by 16 per cent, the registration of electric cars in 2020 increased by almost 41 per cent (International Energy Agency (IEA), 2021a). Almost three million cars were sold last year globally, making a share of 4.6 per cent in total sales.In 2020-21, the European market overtook China for the first time as the top market which is then followed by the United States (Perkins and Fox, 2021). In 2021, the figure for plug-in electric cars reached an all-time high of approximately 6.5 million, which is 108 per cent more than its value in 2020 (Inside EVs, 2022). **Figure 2** describes the global number of electric vehicles in the past five years, and the countries that have dominated the EV market. Among different categories, passenger transport occupies the largest share.

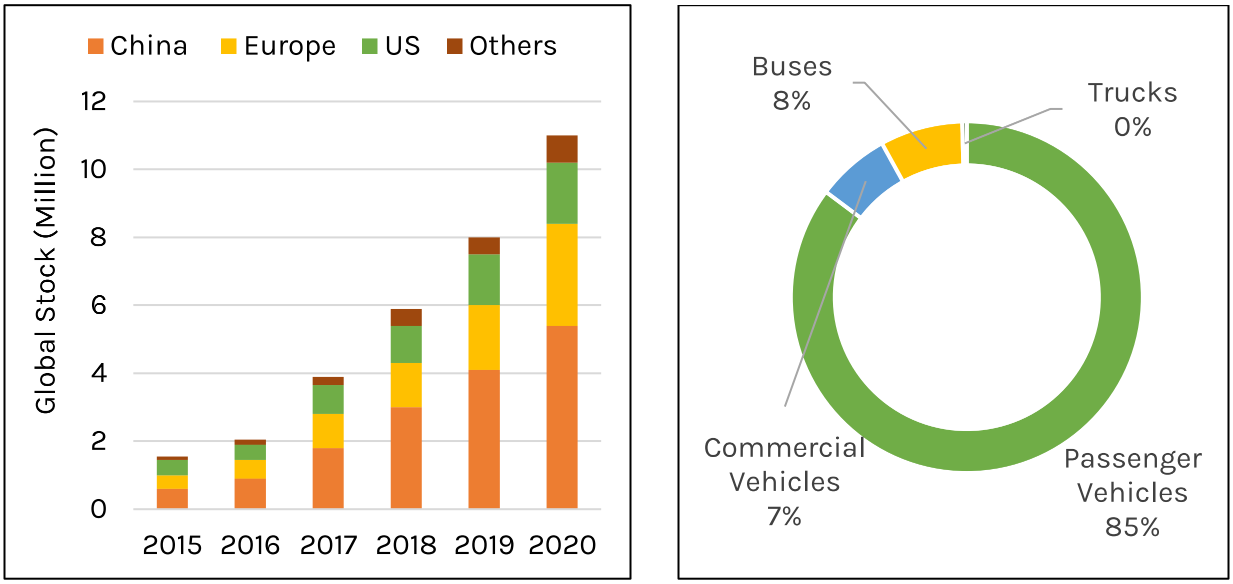


Figure 2 The global stock of electric vehicles and the share of transport modes [Source: Figure designed by the authors through data obtained from the IEA reports].

For the accelerated growth of EV market, some major global initiatives and multi-governmental policies have been launched. Under Clean Energy Ministerial (CEM), an Electric Vehicle Initiative (EVI) was launched in 2010 which recognized the socio-economic prospects of EVs in comparison with fossil fuel-based vehicles (Clean Energy Ministerial (CEM), 2010). Major campaigns and implementing actions launched under CEM are highlighted in **Figure 3.**

Figure 3: Major global campaigns and implementing actions to support EV growth [Source: Figure designed by the authors through data obtained from (CEM, 2021), (GCVDZ, 2021), (IEA, 2020a)]

Along with these initiatives, the spending of consumers for EVs has also increased substantially. In 2020, the customers have spent around $120 billion across the world for EV purchase (International Energy Agency (IEA), 2020b). This is 50 per cent more as compared to its 2019 value. However, when compared with the increase in sales, i.e. 41 percent, there is an average price increase of 6 per cent. This also reflects that the European market has a higher share since the average cost of EVs there is higher as compared to that in the Chinese market.

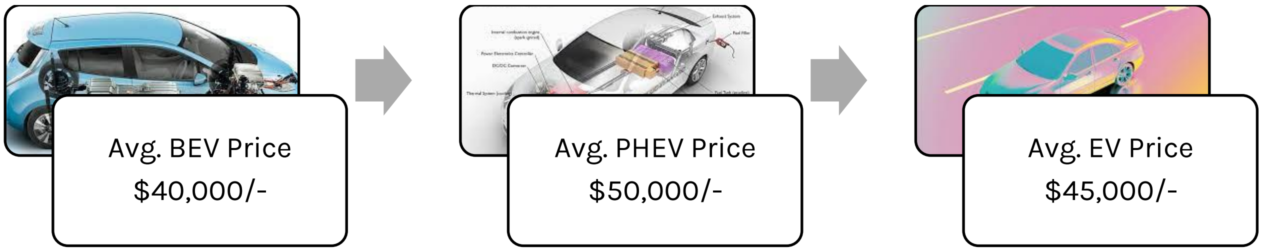


Figure 4 Average Global Prices of Electric

In 2020, the public sector spent approximately $14 billion on incentives and tax deductions and exemptions. This represents a 25 per cent increase on year-on-year basis. However, as compared to the 2015 level, still there has been a decline of around 10 per cent incentivization in 2020 (ibid). The fact that the European market overtook China was also supported by its more ambitious incentivization. Both Europe and China introduced a price cap under which subsidies were not given for vehicles having the threshold above a certain value.

With these friendly regulatory conditions in most countries, the number of global EV models has also changed significantly. In 2020, there were 370 EV models which was 30 per cent larger than the number in 2019. The largest number of models is still being offered by China. However, the largest increase in the past year came from Europe. BEVs are found in most categories while plug-ins were mainly in larger segments. Over the same period, the technology has also significantly improved. The approximate range of a BEV in 2015 was around 200 kms. In 2020, the approximate value has crossed 350 kms. For PHEVs, the range is still very much constant, i.e., around 50 km (ibid).

For original equipment manufacturers, electrification of this segment has been driven majorly for Sports Utility Vehicles (SUVs) because of a comparatively faster growing segment, higher profit return, rapid transition for emission targets, and credit schemes in Europe. Still, a growth is observed in each category. **Figure 5** below maps the major manufacturers across the globe along with their proposed targets for coming up with new models for electric vehicles.

	Model	Min EV Models (2030)	Min % EV Sales (2030)
1	BMW	25	25
2	BAIC	2	50
3	Changan Automobil	33	0
4	Dailmer	10	50
5	Dongfen	5	30
6	FAW	0	60
7	Ford	40	100
8	GM	30	0
9	Honda	0	40
10	Hyundai Kia	29	0
11	Mazda	1	5
12	Renault Nissan	20	20
13	Maruti Suzuki	1	0
14	SAIC	30	30
15	Stallantis		35
16	Toyota	16	0
17	Volkswagen	75	50
18	Volvo	4	100

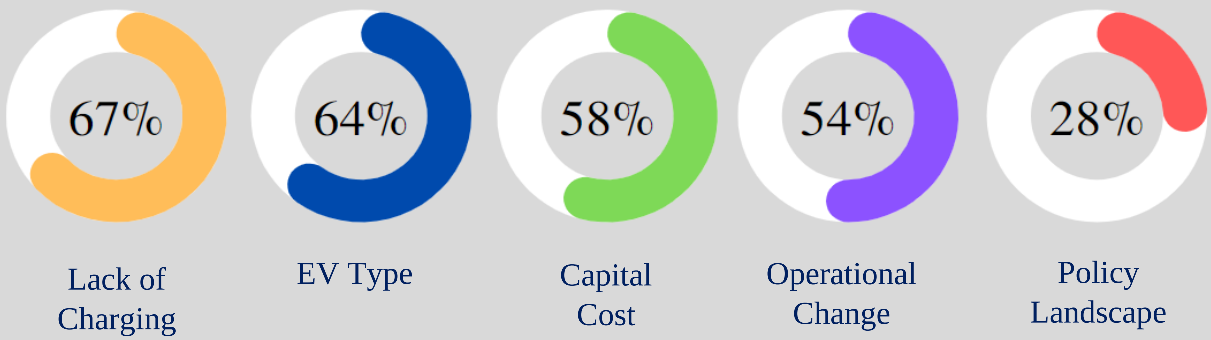
Figure 5 Light Duty EV targets of largest OEMs [Source: Figure designed by the authors based on data from IEA reports]

For buses and electric trucks, China has largely dominated the global market with the introduction of around 78,000 new buses and 7400 new trucks in 2020 which represents an increase of 9 percent and 10 percent respectively as compared to 2019

(Huang *et al.*, 2021). Although the numbers do not compare to passenger or commercial vehicles, the scope of EVs in this category has also broadened over the past years. Along with buses, the demand of trucks has compelled many OEMs to expand their production lines. Many truck manufacturers, such as MAN, Volvo, Renault, and Daimler have foreseen an all-electric mobility future.

Box 1: BARRIERS TO ADOPTION OF ELECTRIC VEHICLES BY EV-100 MEMBERS

The EV-100 initiative by Climate Group (Group, 2017) is bringing together around 100 companies (in 80 markets) that are looking for electric vehicles to be the norm in 2030, which means that a total of 4.8 million vehicles will transition to electricity and over 6,500 charging stations will be installed by 2030. The EV-100 members have reported that the availability of charging infrastructure is the most critical barrier followed by non-availability of the flexible technology types. Figure shows that on a rank of Most Significant to Least Significant, EV-100 members have highlighted the following key barriers for EV adoption.



Although the highest charging work is still being carried out in homes, a large-scale development will require massive uptake of publicly accessible charging stations. As of 2020, there were globally around 1.3 million publicly available charging stations, of which 30 per cent were fast chargers. Most countries, however, failed to meet their desired targets of Electric Vehicle Supply Equipment (EVSE) for 2020. Korea had the highest ratio of 0.42 EVSE per EV followed Chile and Indonesia (Korea-EU Research Centre (KERC), 2022).

1.3. Energy Outlook of Pakistan's Transport Sector

As per the record of Pakistan Automotive Manufacturers Association in 2021, Pakistan had an annual production of 2247346 vehicles and annual sale of 2245862 cars (PAMA, 2021a, 2021b). Further categorization is given in **Figure 6** while segregation of different vehicle categories is depicted in **Annexure 1.**

	Model	Production (2021)	Sales (2021)
1	Trucks	3,808	3,695
2	Buses	570	652
3	Jeeps	11,328	11,306
4	Pick-Ups	19,744	18,909
5	Farm Tractors	50,751	50,920
6	2/3 Wheelers	1,902,415	1,903,932
7	Passenger Cars	258,730	256,448

Figure 6: Annual Production and Sales of Vehicles in 2021 [Source: Figure designed by the authors through data published by PAMA]

Between 2013-2019, the energy consumption of Pakistan's transport sector grew with a compound annual growth rate of 5.7 per cent (Pakistan, 2020). Between 2020 and 2021, the growth declined by around 6 per cent due to imposed partial and complete lockdown (Hydrocarbon Development Institute of Pakistan [HDIP], 2021). Even in the recovery period, the international travel is very limited, and the sector has not recovered to its pre-COVID levels (Aslam *et al.*, 2022). **Figure 7** presents the energy consumption from transport sector in 2020 and fuel share in the total energy consumption of the transport sector.

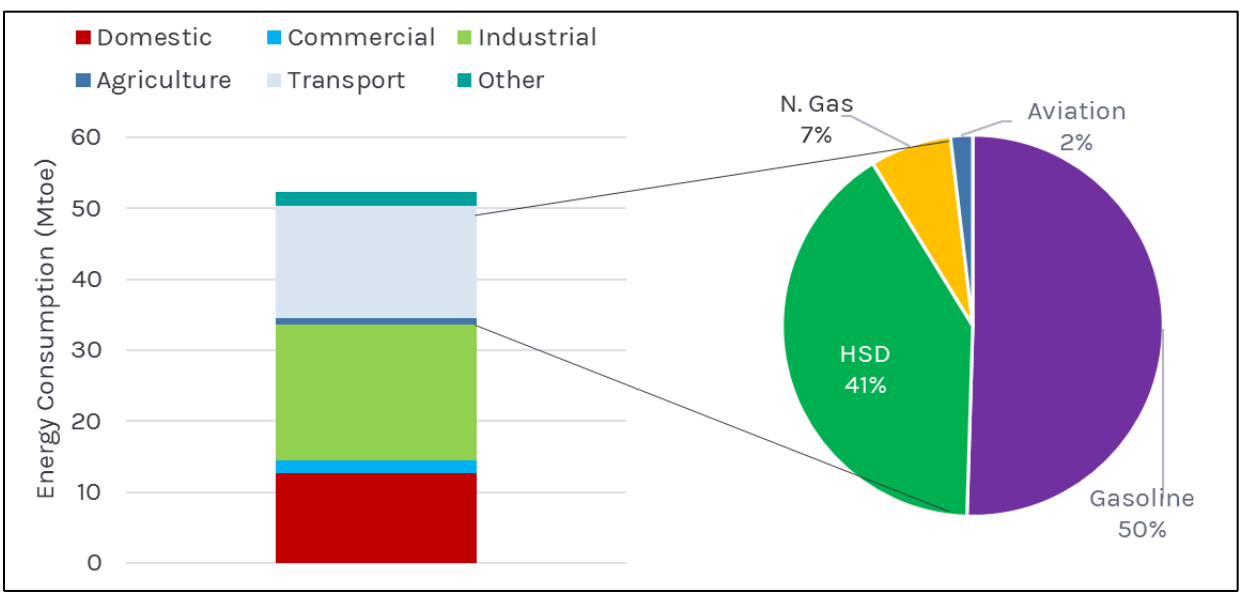


Figure 7: Energy Consumption and Fuel share of Pakistan's transport sector [Source: Figure designed by the authors through data obtained from Pakistan Energy Yearbook 2020]

Box 2: PAKISTAN'S CLIMATE PROFILE AND DEVELOPMENT INDICATORS

- **NDC Targets:** Revised Nationally Determined Contributions of Pakistan have targeted a 50 per cent emission reduction by 2030 (15 per cent from the country's own financial resources and 35 per cent subjected to international funding). Between 2012-2018, Pakistan's GHG emissions, including LULUCF has grown at 8.5 per cent to a value of 2.18 tCO_2eq per capita (Ministry of Climate Change, 2021).
- **Socio-Economic Context:** Annually, Pakistan suffers around 500 fatalities (0.3 per 100,000 people which is ranked 19th amongst 181 countries) and $3.79 billion in losses due to extreme weather conditions (0.53 per cent of unit GDP) (Climate Transparency, 2020). As per the NDCs, Pakistan has adaptation needs of $6-14 billion per year where 70 per cent goes to infrastructure damage loss. A clean energy transition would require a total of $101 billion by 2030. In 2019, Pakistan had a Human Development Index of 0.560. Around 36.7 per cent of its population lives in urban areas, which is also expected to go beyond 50 per cent by 2050. Fifty million people in Pakistan still lack access to grid electricity due to the absence of transmission infrastructure (Sustainable Development Goals [SDGs], 2019).
- **Energy Related CO_2 Emissions:** As per 2019 statistics, Pakistan's biggest driver of GHG emissions was CO_2 from combustion of fuels. The sectoral share of CO_2 emissions is: industrial (32 per cent), buildings (11 per cent), transport (28 per cent), power (27 per cent), and others (2 per cent) (Climate Transparency, 2020).
- **Energy Profile:** In 2021, Pakistan had a generation share of 31 per cent from hydro, 3 per cent from wind, 1 per cent from RFO, 25 per cent from Coal, 19 per cent from RLNG, 12 per cent from gas, 8 per cent from nuclear, and below 1 per cent from bagasse and solar (National Transmission and Despatch Company (NTDC), 2021). In 2019, the energy supply of Pakistan was 21GJ/capita, which increased by almost 9 per cent between 2014-2019. The energy intensity of the economy is 4.34 TJ/PPP (National Electric Power Regulatory Authority [NEPRA], 2021).
- **Financial Flows:** In 2018, Pakistan spent $5047 million on fossil fuel subsidies. 52 per cent was for gas and 46 per cent for electricity (Federal Budget 2018). According to IEA, Pakistan subsidized FF for $1.9 billion in 2019. As per the government, a subsidy of $1.7 billion was presented in the state budget for electricity, oil and gas in fiscal year 2019-20. Most of the subsidies for electricity are for DISCOs. Further, the government had to incur $820 million in foregone revenues or FF production and sales in the form of tax expenditures.

1.4. Need to Transition Towards Electric Mobility

The transport sector of Pakistan is completely based on imported fuels that is a major threat for the country's trade deficit. As of January 2022, the trade deficit of Pakistan surged to $24.79 billion in the first half due to 63 per cent increase in the year-on-year basis (Ani, 2022). With the projected increase in the travel demand, this deficit is expected to cause a major burden for the national exchequer. Between 2013 and 2018, it accounted for 76 per cent of total oil consumed in the country. Transport accounts for 40 per cent of air pollution in the country (Private Financing Advisory Network (PFAN), 2021). It was the second largest contributor of CO_2 emissions in 2019. Between 2013 and 2018, transport sector depicted a per capita increase in the emissions of around 44 per cent with an average per capita value of 0.27 CO_2eq. In this context, a transition towards electric vehicles in the country can provide multiple socio-economic benefits as explained below (summarized in **Figure 8**) [(Profit, 2022).

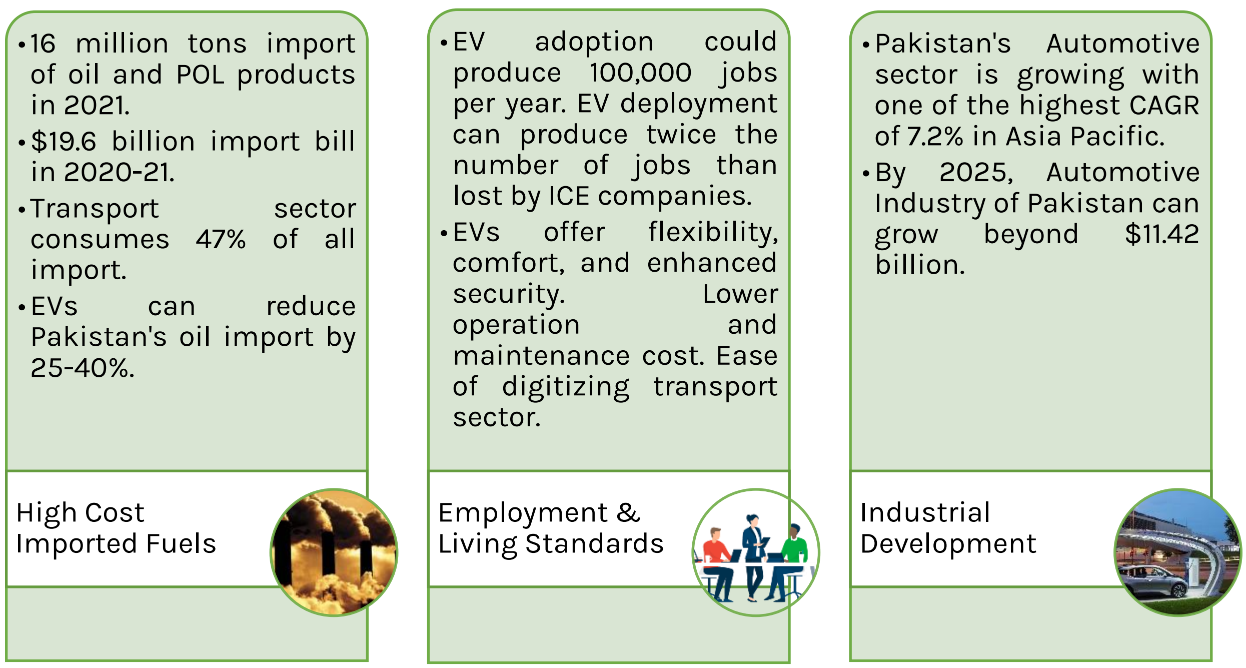


Figure 8: Economic Opportunities for Promoting EVs in Pakistan

1.4.1. Transition from High-Cost Imported Fuels

In 2022, Pakistan had to spend over $19.3 billion on the import of oil (Profit, 2022) and this cost is expected to cross over $30.7 billion by 2025 (Akram, Raza and Mustafa, 2021). In the later half of 2021 and first quarter of 2022, Pakistan has already seen a marked inflation in the price of both petroleum and gas products. The limited supply not only affected the transport but also the industrial and power sector. In Pakistan, transport is a major source which consumes around 47 per cent of all imports. Therefore, given this pace and growth of the sector, Pakistan could face major challenges of financial cost and production charges. Under these circumstances, the transition towards EVs can reduce oil dependency which will reduce burden on the national exchequer. Research indicates that even electric vehicles are charged using coal and other fossil fuels, this shift can reduce Pakistan oil import by 25-40 per cent. Further, due to other tangible benefits, such as low service requirement and use of lubricants, it reduces dependence on other imported petroleum products as well.

1.4.2. Employment Opportunities

A large-scale adoption of electric vehicles would lead to an increase in employment, with manufacturing industries of chargers and manufacturers leading the market. As per the study conducted by the National Renewable Energy Laboratory (NREL), EV adoption could potentially lead to the creation of 100,000 jobs globally per year (National Renewable Energy Laboratory {NREL}, 2021). Although there is a possibility of decline in the job market for petroleum and refining industries, as per the results of AIE, EV employment supply chain could produce twice the number of jobs as lost by the other companies relevant to ICEs. However, the study also indicates that for a just transition, capacity building and training for new skills must be advocated.

1.4.3. Living Standards

Along with many ICE cars, electric vehicles offer flexibility, comfort, and enhanced security. They have lower operating cost, less maintenance is required since they do not have any moving parts, and the potential of digitalizing the system for EVs is comparatively easier (Rajper and Albrecht, 2020). Although the range of EVs is still a major issue in countries that lack infrastructure development and availability of fast chargers (Mandys, 2021), the potential places (homes, offices, charging stations) for charging a battery in EVs is larger. Noise levels in Pakistan are reported to be between 72-86 decibels. Since EVs are battery operated, resulting noise levels can be significantly controlled. Use of batteries further add to vehicular safety as the absence of a combustion engine nullifies the threat of an unfortunate sudden explosion.

1.4.4. Industrial Development and Green Business Opportunity

The automotive sector of Pakistan is among the fastest growing industrial sectors with a Compound Annual Growth Rate (CAGR) of 7.2 per cent (Pakistan Automotive Manufacturers Association PAMA), 2021a, 2021b). By 2025, it is expected to grow beyond $11.42 billion. However, as opposed to the growth in other countries which has shifted to zero-emission vehicles, Pakistan is still relying on the ICE vehicles. A transition towards electric mobility can, thus, provide numerous opportunities in the whole manufacturing process supply chain, including opportunities for foreign export companies, local manufacturing and assembly, transportation, telecommunication, energy, chemical, mining, etc (Noel *et al.*, 2018). It is also evident since BYD (Chinese) have signed a contract with Toyota to develop EVs in Pakistan (Ansari, 2019). Other Chinese companies, such as Weifang, Shandong, Shanghai, Shenlong Bus, Wuxi Shengbao EV, etc., have also signed MoUs for bringing EVs in Pakistan.

1.4.5. Surplus Power Capacity and Demand Curve

Currently, Pakistan is operating in a surplus-capacity mode. The existing capacity of the country is around 40,000 MW with maximum demand reaching around 28,000 MW in summers (NEPRA, 2021). Since Pakistan has to pay a high cost in the form of capacity payments, this surplus capacity can be utilized through electricity requirements of the EVs (Nicholas, 2020). Further, overnight charging of the EVs in homes can also flatten the peak of electricity demand curve, thus reducing load in the working hours.

1.5. Scope and Objectives

Given the global shift towards EVs and transport sector challenges of Pakistan, transition from ICE-based vehicles to electric mobility is the need of hour. This will not only make an economic impact on the country's trade deficit, but also contribute to improvements in Pakistan's environment profile as prescribed under the Nationally Determined Contributions (NDCs).Given this backdrop, there is a need to analyze the potential impact of EVs on Pakistan's transport sector. Key objectives of this study include:

1. To analyze the policy and regulatory support for EVs in Pakistan and benchmarking it with International best practices.
2. To Understanding market preparedness and industrial readiness of electric vehicles in Pakistan.
3. To Model the socio-economic impacts of penetrating electric vehicles in Pakistan's transport sector through the use of Low-Emission Analysis Platform (LEAP) model.
4. To recommend the way forward for rapid off-take of electric vehicles in Pakistan.

To achieve these objectives, this study uses the following methodological approach:

- **Desk Review Assessment:** An extensive desk review has been conducted on the local and international transport sector, thus identifying the local and global challenges and key priority actions that have taken to overcome the decarbonization and economic challenges of the transport sector.
- **Consultative Discussion:** To analyze the view of relevant stakeholders on the given topic, a consultative discussion of stakeholders was conducted on "Market preparedness and policy support for Electric Vehicles (EVs) in Pakistan[1]". The key takeaways from the consultative discussion are incorporated in both modeling and policy framework of the study.
- **Low-Emission Analysis Platform (LEAP) Modeling:** LEAP model has been designed specifically for the transport sector of Pakistan to quantify the socio-economic and energy demand impacts on the transport sector through penetration of EVs under different scenarios.

[1] Consultative Discussion: https://www.youtube.com/watch?v=VD5qSe3mXGM&t=63s

2. CHAPTER 2: POLICY AND REGULATORY SUPPORT FOR RAPID UPTAKE OF ELECTRIC VEHICLES

This section initially describes the best practices and policy support that led to the increased penetration of electric vehicles across the world. It further provides key insights into the existing policy landscape and regulatory measures taken in Pakistan to support both infrastructure and stock of EVs.

2.1. Global Policy Support for Electric Vehicles

This decade (2020s) has already been a critical year for mass electronification of the transport sector through introduction of new models, advancement in battery technology and cost reductions, and policy support (International Energy Agency (IEA), 2020b, 2021d, 2021a, 2021c). Fiscal incentives have initially supported the uptake of EVs and scaled up the battery manufacturing process. Policy drivers at various stages of EV introduction are depicted in Figure 9.

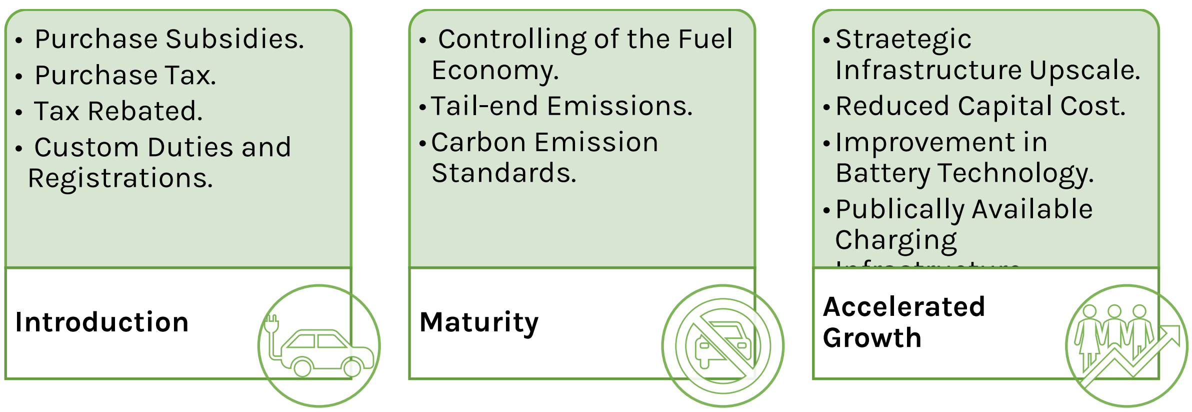


Figure 9 Policy drivers at different stages of EV upscale

To bridge the price gap with FF-based vehicles, the purchase subsidies, vehicle purchase tax and rebates go as far back as the 1990s in Norway, 2010 in the US, and 2014 in China (Aasness and Odeck, 2015). This was gradually followed by controlling of the fuel economy and tail end carbon dioxide emissions. As of today, around 85 per cent of the global car sales has a binding to follow these standards. Going further with an accelerated pace, there is a need to come up with easily accessible public charging points along with improvements in battery technology to reduce capital cost.

As of 2020, at least 20 companies have announced the phase-out plans of ICE vehicles over the next 30 years while around 120 countries have announced their net zero emission pledges. Although the policy support is comparatively less supportive for heavy-duty vehicles, this needs to be addressed in a similar manner LDVs were addressed 10 years back. This may include green public procurement programmes, tenders, subsidizing, and providing direct support for the development of infrastructure.

Box 2: REGULATORY INSTRUMENTS FOR EV UPSCALE

EV growth requires ambitious policy initiatives and building upon the existing ones for both global leaders and new ones. Some examples of these initiatives include the following:

- **European Union: CO_2 emission regulations for cars and vans:** This regulation sets CO_2 emission targets for the European fleets for 2020, 2025, and 2030, along with strategies for the upscaling of ZEVs and LEVs (International Council on Clean Transportation, 2014).
- **China's New Energy Vehicles (NEV) mandate:** This policy regulated how Chinese "Average Fuel Consumption Credit" and "New Energy Vehicle Mandates" were calculated and traded. Under the phase 2 of this policy (2021), NEV credits percentage targets (DieselNet, 2017).
- **California's Zero-Emission Vehicle Mandate:** This mandate controlled the smog-relevant issues and GHGs emitting from passenger vehicles in California (US). Under the mandate, the percentage credit increases from 4.5 per cent in 2018 to 22 per cent by 2025 (California Air Resources Board (CARB), 2021c).
- **California's Advanced Clean Truck Regulation:** Under this regulation, truck manufacturers between class 2b-8 would sell zero-emission trucks with an increasing percentage. By 2030, ZEV trucks will be 55 per cent of 2b-3, 75 per cent of class 4-8, and 40 per cent of tractors (California Air Resources Board (CARB), 2021a).
- **Netherland's Zero Emission Commercial Vehicle Zone:** 14 cities in the Netherlands have mentioned the announcement of zero emission z ones in the city, which means that in five years, they will only have emission-free delivery vans and lorries (Government of Netherland, 2021).
- **Other EU Plans and Policies:** For the promotion of electric mobility, a number of initiatives were taken, including decarbonization commitments in the EU Green Deal, Next Generation EU, and EU Sustainable and Smart Mobility Strategy & Action Plan. Further, many regulations were given regarding performance standards, charging infrastructures, batteries, and pollution standards (European Union, 2021).
- **Other China's policies and plans:** China extended its subsidy programme in 2020 by putting a vehicle price cap and NEV sale limit of 2 million per year. Further policies for battery recycling, charging stations, and FCEVs were also announced in 2020.
- **Other US Policies and Plans:** US revised its corporate average fuel economy standard to safer, affordable fuel efficient (SAFE) vehicle standard. In 2020, the US came up with $7500 federal tax credit for EV purchase. Other policies also include low carbon fuel standards, tax credits (state-wise), and

financial/technical assistance for infrastructure development (California Air Resources Board (CARB), 2021b).

- **Stimulus Programmes for EVs** (International Energy Agency (IEA), 2020c)
    - Germany announced 8 billion euros for the support of EVs.
    - France announced subsidizing the EVs.
    - Italy announced bonus on EV purchase and hybrid vehicles.
    - Spain announced a scrappage scheme.
    - China extended the subsidy programme for BEVs and PHEVs to 2022.

Along with the ease of EV penetration, policies and regulations for the development of charging infrastructure are also well established across the world. Major battery support initiatives across the world are highlighted in Figure 10. A major initiative in this context was the "Alternate Fuel Infrastructure Directive" announced by the European Union which guides publicly accessible charging stations (European Union, 2020). As per AFID, the EU members will develop publicly accessible charging stations with a ratio of one charger per 10 electric cars. Under the Euro Green Deal, a total of one million charging stations will also be installed by 2025.

The EU countries have also initiated an Energy Performance of Building Directive (EPBD-III) which requires that both residential and non-residential buildings will improve their access of potential charging points. China also announced a $1.4 trillion Digital Infrastructure Public Spending Programme under which the funding for EV charging stations will increase.

The US infrastructure plan that was proposed in 2021 would also include a grant that incentivizes installation of 500,000 charging points. Further, many countries have put forward their plans for infrastructure development as highlighted extensively in the IEA report on "Global EV Outlook 2021".

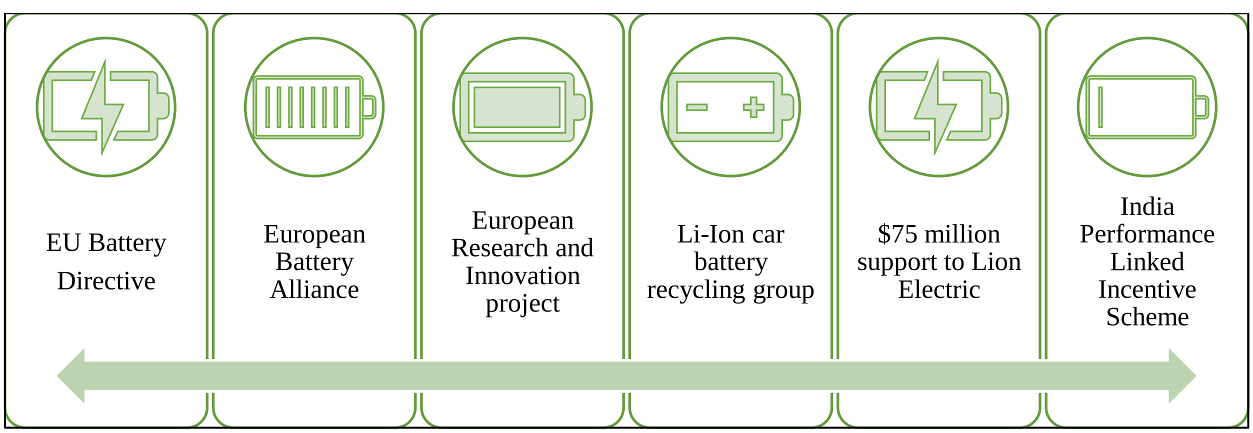


Figure 10 Battery Support Initiatives across the World

2.2. Best Practices Across the Globe in Short (1-3 years) and Medium-Term (3-5 years) Growth

This section describes key policy measures and interventions taken by different countries for the introduction and large-scale penetration of electric vehicles in their fleet. An extensive policy literature was conducted for 10 different countries (China, USA, Germany, India, France, UK, Norway, Sweden, Japan, and California). The inputs obtained from the international experts in the Consultative Discussion on Market Preparedness and Policy Support for Electric Vehicles in Pakistan were also incorporated to understand the global driving models. The key practices that proved successful in both short and medium term are as mentioned in **Table 1** (Bakker and Trip, 2013; Barton and Schütte, 2017; Berkeley, Jarvis and Jones, 2018; Habich-Sobiegalla, Kostka and Anzinger, 2018; Vidhi and Shrivastava, 2018; Tarei, Chand and Gupta, 2021; Sathiyan *et al.*, 2022).

Table 1 Best Practices across the world for Upscale of EVs

Sr. No	Intervention	Leading Countries
1	Special incentives and subsidization schemes to reach the "critical mass number" after which the interest of local stakeholders and, consequently, the uptake of EVs can be achieved in a fast-tracked manner. Such schemes are then steadily removed.	China Norway
2	Regulatory push through the introduction of Zero Emission Vehicle Mandate, which restricts any auto manufacturer or importer to produce at 10 percent (or a specific number of the country) of EVs. Trade of purchase credits was also allowed in these schemes	China France Others
3	Regulatory push through Average Vehicle Emission Standards, Fuel Economy Standards, and EV Purchase Incentives	All Countries.
4	The provision of free registration, lower tolls on roads and motorways, preferential parking spaces, and provision of allowance to special bus lanes for EVs only.	
5	Early bird incentives for the purchase of EVs, especially for the four wheelers. These include up to 20 per cent premium for 2-wheelers and 50 per cent premiums for 4-wheelers.	India China
6	Mandatory for all New Real Estate Projects to install EV charging stations.	Proposed (not implemented in All)

7	Scrappage Incentive to be given to customers that are converting their ICE vehicle to EV.	China
8	The provision of an Online Single Window Clearance for providing ease of business and friendly regulatory environment to the private sector representatives.	China Norway
9	Many countries have ensured the initial steps taken through government procurement of the EVs. This is then to be followed by the conversion of commercial fleet and mass transit systems.	Most countries
10	The development of EV infrastructure through direct involvement of state-owned electricity utilities and distribution companies.	Most counties.
11	Local governments and municipalities developed regulations for fast and low-cost processing of number plates for electric vehicles as compared to ICE vehicles.	France China
Medium Term Interventions		
1	For improved standardization, a Standard Protocol has been developed between battery management system and developer of motor controller.	India China Norway
2	Introduction of capacity-building programmes for promoting new skills required to ensure a just transition of both industry and workers.	Most countries
3	Standardization of battery packs through inter-operate ability.	
4	Introduction of UIN system (Unique Identification Number System) to ensure compliance of electric vehicle safety standards.	Japan

2.3. Policy and Regulatory Landscape for Electric Vehicles

The policy support for EVs was initiated in 2019 after the introduction of Pakistan's first ever National Electric Vehicles Policy (NEVP) by the ministry of climate change, government of Pakistan (Ministry of Climate Change, 2019). The policy after introduction was shortly approved by the federal cabinet under the leadership of the prime minister. The critical objectives of this policy were focused on mitigating the impacts of climate change through the reduction of emissions from the transport sector, creating green jobs, reduction of petroleum imports, stabilizing the electricity demand curve, mobilizing the industrial growth, and encouraging the transport industry for a transition towards EVs. The key targets for different vehicle types under NEVP 2019 are as shown in **Figure 11** while various regulatory support measures are separately highlighted in **Table 2.**

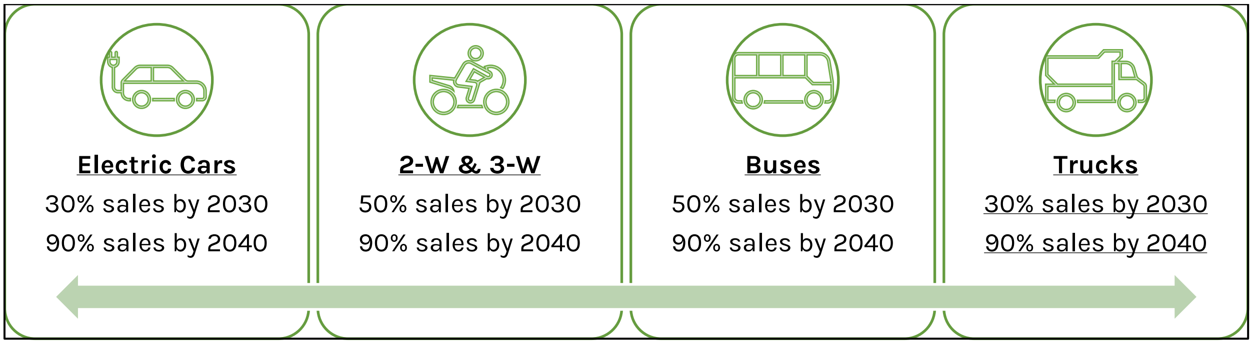


Figure 11 Targets for different vehicle categories in NEVP 2019 [Source: Figure designed by the authors based on targets of NEVP]

Although the NEVP was approved by the cabinet, its draft was, however, referred to MoCC based on the observations raised by Pakistan Automotive Manufacturers Association (PAMA) and other ministries (Ansari, 2020). The critical factors leading to this observation were the lack of focus on the indigenous industry and the import of used EVs. The task of formulating the final policy was then also taken by an inter-ministerial committee consisting of the following members:

- The ministry of Industries and Production (MoIP), Government of Pakistan [Chairperson/Head]
- The ministry of Science and Technology [Member]
- Advisor to the Prime Minister on Climate Change [Member]
- Chairman, Federal Board of Revenue [Member]
- Other government officials [Members]
- The ministry of Planning, Development, and Special Initiatives (MoPD&SI) [Secretariat]

Following this, the Engineering Development Board (EDB) put forward the Electric Vehicle Policy 2020-25 for 2-3 wheelers and heavy commercial vehicles (Ministry of Industries and Production Government of Pakistan, 2020). While declaring the targets of NEVP 2019 to be ambitious, this policy has its major focus on value creation of the local industry. Key objectives of the policy revolve around a pivotal industrial growth, mitigating climate impacts, local job creation, and reducing the external deficit through import reduction. Various incentives introduced for different categories of vehicles mentioned in this policy are highlighted in the Table 2.

While the policy by EDB focusses mainly on 2-3 wheelers and heavy commercial fleet, the subsequent measures for 4-wheelers, including cars, LCVs, and SUVs were given under the Auto Industry Development and Export Policy 2021-26. The policy was approved by the Federal Cabinet in 2021 after making some amendments in the initial version submitted in June. AIDEP 2021 also provides incentive schemes for various categories, including the hybrid vehicles as highlighted in the Table 2.

As discussed above, there has been effective debate on incentives, targets, and ownership of policy, but its enforcement and implementation remains a challenge. The policy targets have not been fully implemented across Pakistan in terms of waiver of registration fee and token taxes being a provincial subject.

Table 2: Incentives for Electric Vehicles Under Different Policies in Pakistan

Policy	Incentives for Vehicles		
	2-3 Wheelers	**Cars, SUVs, etc.**	**Busses & Trucks**
NEVP 2019	1. Incentives mentioned in AIDEP 2016-21 will remain intact. 2. 2-3-Wheeler CKDs can have import at 1% CD and 0% ST. 3. Locally manufactured vehicles will have 1% ST. 4. Exemption from registration fee and annual token tax. 5. EV specific parts and components that are not locally manufactured (compliant to UNECE) will be allowed at 1% custom duty and 0% sales tax.	1. Incentives mentioned in AIDEP 2016-21 will remain intact. 2. Removal of Additional Custom Duty and Additional sales tax on import of EVs 3. EV specific parts and components that are not locally manufactured (compliant to UNECE) will be allowed at 1% custom duty and 0% sales tax. 4. 4-wheelers cars will not have FEDs. 5. locally manufactured ECs (up to 50 kW) and LCVs (150 kW) will be sold at 1% of tax. 6. Exemption of Registration fee and annual renewable fee. 7. SBP to allow purchase of new EVs under GBGs. 8. EVs to pay only 50% of the toll tax.	1. Busses and trucks import at 1% CD. 2. for locally manufactured busses, the import of all parts will be at 1% CD. 3. CBU and CKD import for purpose of manufacturing will be at 1% CD (Until AIDEP 2021 comes in place). 4. Buses and Trucks will have no registration or annual token tax fee. 5. SBP to allow purchase of buses and trucks under GBGs. 6. Metros to be prioritized. 7. EV parts of trucks will be at 1% CD applicable to non-localized parts (till announcement of AIDEP 2021). 8. Sales tax for locally manufactured trucks will be 1% at sale stage. 9. Trucks will be exempted from permit cost.
	Incentives for Infrastructure		
	Manufacturing Units	**EV Components and Modules**	**Charging and Battery**

	1. Incentives provided in AIDEP were upheld. 2. For EV manufacturers, equipment and plant will be at 0% CS and 0% tax. 2. Import of machinery and equipment for developing EV will not have CD, ST, and Income WT. 3. SBP may allow lower financing rates for plants under LTFF.	1. All motors, batteries, and electronic components apart from the ones that are locally manufactured will be allowed import at 1% CD and 0% ST. 2. All individual components of batteries and etc. will be allowed at 1% CD and 0% ST. 3. Manufacturing conversion kits will be allowed at 1% CD. 4. 5-year income tax exemption for setting EV related equipment manufacturing facility. 5. All machinery for manufacturing of EVs will be exempted from duties and taxes for 5 years. 6. For manufacturers, loan at 5% will be given to registered manufacturers.	1. Charging equipment will be allowed import at 1% CD 2. Components and modules for Fast DC chargers will be allowed at 1% import CD. 3. In every city, one DC fast charger will be installed in 3*3 km area 4. DC charging stations to be installed along the motorways. 5. Public charging stations may have standardized swappable batteries.
EV Policy 2020-25 (2-3 Wheelers and HCV)	**Incentives for Vehicles**		
	2-3 Wheelers	**Cars, SUVs, and etc.**	**Busses & Trucks**
	1. EV related parts proposed at 1% CD 2. Non localized parts (non-EV) at 15% CD. 3. Localized Parts at 46% CD. 4. Sales tax fixed at 1% for locally manufactured 2-3	No interventions for this Category	1. Imports of all parts (both local and non-local) will be at 1% CD. 2. Electric buses & Trucks will have no registration fee or annual token tax. 3. SBP may allow purchasing under GBGs. 4. CD on hybrid electric trucks will be at 1% on sale stage while import of

	wheelers. 5. Import Sales tax is 0% on CKDN		inputs/CKD will be exempted from sales tax.
	Incentives for Infrastructure		
	Manufacturing Units	**EV components and modules**	**Charging and Battery**
	1. Incentivized power tariffs for charging stations. 2. Loans shall be given at 5% for EV parts manufacturers. 3. Bulk insurance to happen at concessional rates. 4. For auto part manufacturers, income tax exemption for five years to be granted.	0% CD and taxes on machinery and equipment for EVs. 2. 10 CBU units (for each variant) to be allowed at 50% of prevailing custom (200 units max).	
AIDEP 2021-26	**Incentives for Vehicles**		
	2-3 Wheelers	**Cars, SUVs, and etc.**	**Busses & Trucks**

	1. CD for EV parts at 1% incl. battery, motor converter, charger, etc. 2. ST to be at 1% of sales for locally manufactured 2-3 Wheelers 3. ST at import stage to be waived off. 4. Interventions of imports of CBU.	1. CD on EV parts will be at 1% 2. CKD non-localized will have 10% CD and CKD non-localized will have 25% CD. 3. VAT will be exempted at the import stage.	1. Import of both local and non-local parts at 1% CD. 2. ST to be charged at 1% at sales for locally manufactured. 3. ST waived off at import stage 4. CD on import of completely built units will be 1%.
	Incentives for Infrastructure		
	Manufacturing Units	**EV components and modules**	**Charging and Battery**
	1. 0% ACD on manufacturing of EVs 2. Import will be duty free for plant and machinery of EVs. 3. EV charger imports to attract 1% CD and 0% ACD. 4. EVs will be exempted from FED	Incentivized power tariffs for charging stations. 2. Bulk Insurance at concessional rates.	

2.4. Taxation Regime for Electric Vehicles

As highlighted above in Table 1, AIDEP 2021-26 (Ministry of Industries and Production (MoIP), 2021) announced that the sales tax on local electric vehicles will be slashed from 17 per cent to just 1 per cent while the customs duty on specific EV parts will also be fixed at 1 per cent. AIDEP was the only policy which provided incentives for hybrid vehicles under which the sales tax for local vehicles will only be 8.5 per cent while the customs duty for relevant parts will be 3-4 per cent. However, shortly after the introduction of AIDEP, the government of Pakistan through a supplementary finance bill in late 2021 proposed an increase in sales tax on both electric and hybrid vehicles. On imported EVs, the sales tax was proposed to increase from 5 per cent to 17 per cent for electric vehicles and from 8.5 percent to 12.5 percent for hybrid vehicles. As per government officials, the decision was taken to revive the much-needed IMF program. Now, the cumulative impact of all taxes would account for almost 35 percent.

Following this, the Govt of Pakistan at the very start of 2022 approved the regulatory duties on all imported vehicles. For CBUs of EV battery packs above 50 kWh, the imposition of 10 per cent regulatory duty was approved. For hybrid vehicles having an engine capacity between 1500-1800 cc (CBU condition), the regulatory duties were increased from 15 per cent-50 per cent. In June 2022, the Standing Committee on Finance, Revenue and Economic Affairs recommended to increase the levy of 12.5 per cent on EVs up to 50kWh. The finance bill proposed that taxes will increase from 12.5 per cent to 17 per cent on imported CBU EVs.

Box 2: Key events highlighting the developments in EV landscape

Along with incentives mentioned under different policies for EV upscale in Pakistan, following developments had taken place over the past two years in the EV scenario:

- The registration process for the owners of EVs was introduced by the government of Sindh.
- In August 2021, the federal minister for energy announced that Pakistan will start the local manufacturing of EVs by the end of 2021. The government will offer the private sector full support in developing infrastructure for the growth.
- Pakistan's first ever fast-charging station dubbed as Libra Charging Hub was installed in Karachi. It has 160 kW fast chargers that can charge 80 percent of the car in 15 minutes. The station was unveiled by two leading German companies, i.e., Audi and Siemens.
- Two EV charging stations were installed at Bhera and Pindi Bhattian near M2 Motorway. Tesla motors was responsible for designing and installation of the charging stations. The stations have 60 kWh and 120 kWh chargers.

- The first-ever EV charging station was installed in Karachi through the collaboration of Shell Pakistan Limited and K-Electric. The station was installed at Rashid Minhas Road in Gulshan-e-Iqbal. Shell's second charging station is also installed in Karachi at Gadap Town.
- Pakistan State Oil (PSO) has developed an EV charging point at Capri Gas station in F-7 Islamabad.
- Pakistan's first ever EV charging station was opened by Dewan Motors Pakistan in Lahore's Emporium Shopping mall.
- An MoU was signed between Dewan Motors and FWO for developing charging stations on the motorway.
- To boost industrial growth for EVs, the Gauss Auto Group (Chinese) announced that it will set up an EV plant in Karachi's Special Economic Zone (SEZ).

2.5. The Existing Policy and Regulatory Lag in Pakistan

The policy support for driving technology growth is through five key indicators mentioned in **Figure 12.** Based on both international and national policy discussion given above, the key lagging areas for EV growth in policy and regulatory landscape are as highlighted below:

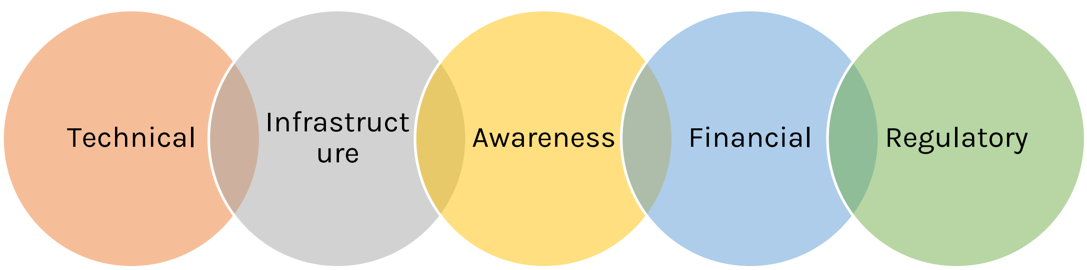


Figure 12 Characterization of critical barriers for EV adoption.

2.5.1. Ownership of Electric Vehicle Policy

After the introduction of EV policy in 2019, an extensive debate was started on the real custodian and developer of the policy. The ministry of climate change initiated the process, but faced significant challenges from the ministry of industries and production who believed that the policy comes under the mandate of the industries ministry. Although the policy was approved by the cabinet, many industrial units labelled the decision as ad-hoc.After the launch of NEVP 2019, the Engineering Development Board categorized the targets of EV policy to be ambitious and put forward a 2-3-wheeler and Heavy Commercial Vehicle Policy in 2020. The policy regulation for 4-wheelers later came through AIDEP 2021. Even in 2022, the policy is being discussed by various ministries with a limited implementation framework.

2.5.2. Non-Compliance with Policy Targets

Based on the EV policy targets of achieving a market sale share of 30 percent by 2030, Pakistan needs to have a cumulative stock of 100,000 cars, 500,000 2-3 wheelers, 1000 trucks, and 1000 busses by 2025. However, in 2021, Pakistan only had imported 390 new and 14 used electric vehicles (Pakwheels, 2021), lagging far behind its target. Further, as already highlighted in the previous section, the recent taxation figures in the backdrop of economic challenges faced by the country, the incentives for electric vehicles in the country have been removed, thus providing a non-friendly environment to private sector investments.

2.5.3. Lack of Regulatory Support

Based on key interventions highlighted in Table-2, a comparative assessment was made between different countries. The matrix below indicates the progress of Pakistan under each of these categories.

Policy Targets					
Compliance	2-3 Wheelers	Trucks	Buses	Infrastructure installation -	
	High compliance	High compliance	High compliance	Low Compliance	
Standards					
Compliance	Zero Emission Vehicle Targets	Average Vehicle Fuel Efficiency	Fuel Economy Standards	EV Purchase Incentives	Vehicle Safety
	High compliance	Low Compliance	Low Compliance	Low Compliance	Low Compliance
Infrastructure Support					
Compliance	Real Estate Commitment	Infrastructure Tenders	Ease of Business through Single Window Facility		Public Private Partnerships
	Low Compliance	Low Compliance	Low Compliance	Low Compliance	Low Compliance

2.5.4. Lack of R&D Support

For the EV revolution prescribed under the EV policy, there is a need for rapid uptake in local manufacturing, not only of the EVs but also of the relevant components, including batteries, etc. In this regard, the role of the ministry of industries and production and the ministry of science and technology are critical. There is a need to put a broader focus on research and development, but the fact is that there is no funding attached with the MoST for EVs; there is a major disconnect in the EV policy goals of indigenization (Baig, 2021). Further, no models for public-private partnership have been introduced by the government to mobilize infrastructure development through the involvement of the private sector.

3. CHAPTER 3: MARKET AND INDUSTRY READINESS FOR ELECTRIC VEHICLES

The sales in the transport sector of Pakistan have always been dominated by the ICE vehicles. In the past five years, hybrid electric vehicles did get some attention, particularly through some Chinese and other models introduced by Honda and Toyota. However, almost 100 percent of the current market sales is dominated by the ICE vehicles. In the recent past, the automotive sector has undergone a complex transformation, ranging from multi-occasion price hikes as well as a drop due to government's decision to slash the taxes and duties. Apart from the low-demand years (particularly during COVID and other economic recessions), the prices have not gone low except this taxation reform in fiscal year 2020-21 when the excise duties went down by 2.5 percent and sales tax on various categories of vehicles was also reduced (Rana, 2021). With this initiative, the government was trying to make cars affordable for the low and middle-income people.

However, due to the crisis caused by Ukraine-Russia war and the dwindling economy of Pakistan, the State Bank of Pakistan (SBP) had to revise the regulations for auto financing. Under the amendments, the auto financing tenure was reduced from 7 years to 5 years while the debt/burden ratio was reduced from 50 percent to 40 percent (The News, 2021). Further, the maximum financing limit for one person was capped at PKR 3 million while down payment was increased to 30 percent from 15 percent. However, to ensure local production, vehicles up to 1000 cc were exempted from such regulations. Later, in mid of year 2022, the terms were again revised, leading to massive increase in the vehicle cost.

Between July 2021 to June 2020, car prices in Pakistan have increased by almost 55 percent. An extensive debate between the relevant government ministries and departments (PAMA, PAC, MoIP, EDB) and local companies was also initiated when the government tried to analyze the cost structures of these companies which almost all of them declined to provide. However, eventually, the government had to back down from its request due to threats received from the international brands to quit functioning within Pakistan. Under the existing scenario, car sales are expected to decline massively in FY 2022-23. As per the report from JS Research, car sales in Pakistan in the next year (2022-23) would decline by approximately 25 percent.

This section of the report discusses the status quo of the automotive industry in Pakistan along with the key players with focus mainly on the EVs and its existing and future supply chain.

3.1. Existing Local Auto and Battery Market in Pakistan

The GDP per capital of Pakistan is ranked 134th in the world which should have limited the fiscal mobility of the people to own a vehicle (Worldometer, 2017). However, as per a recent report of the USAID, about 53 percent of Pakistani households own a 2-wheeler whereas 9 percent own a 4-wheeler. In total, Pakistan has a ratio of 29 vehicles per 1000 people. As of 2022, the automotive industry of Pakistan is well developed with almost all cars being manufactured or assembled locally. The imported cars mainly include HEVs, PHEVs, luxury cars, busses, and large trailer trucks. Luxury cars are mainly imported as CBUs while others are either imported as CKDs or SKDs. This increase in the local manufacturing was mainly supported by the government's decision in 2018 to put a ban on the import of used vehicles (other than for EVs).

Along with ICE vehicle components, Pakistan also has a battery fleet dominated by lead-acid batteries. These batteries are mainly available with the Universal Power Supplies (UPSs), Solar PV Systems, BTS stations, Reefer trucks, and the existing fleet of EVs. Key insights for each of this category is provided in **Table 3.**

Table 3 Use of Lithium-ion Batteries Across Various Applications in Pakistan

Sr. No	Battery Storage Application	Description
1	UPSs	Due to continuous power outages across the year and high T&D losses, the UPS have experienced a rapid spread across the country. According to USAID study, there are approximately 2.8 million UPS currently present in the country with name plate storage capacity of 2 kWh.
2	Solar PV systems	In recent 2-3 years, Pakistan has observed a marked increase in off-grid solar connection due to ease of regulations by NEPRA. Most of these off-grid solar systems in residential and commercial sector are accompanies by batteries. As per the recent NEPRA state of the Industry Report, there is approximately 202 MW of power generated from these solutions.
3	BTS Systems	BTS systems are deployed across the country to provide backup during power shortage periods. There are approximately 47,000 BTS systems with an estimated battery capacity of 164 MWh (Lithium ion) and 1.6 GWh (AGM)
4	EVs	Electric Vehicles use batteries as the main source of power drive.
5	Reefer Trucks and	These vehicles use batteries to generate required power for cold-supply chains such as food transportability. As of 2022, there

	Food Transporters	were 3000 such trucks in Pakistan operating with a battery capacity of almost 144 MWh.

Details of key players and market progress of each category of vehicles discussed above in the report are highlighted in the following subsections.

3.1.1. The Market of ICE and Electric Cars in Pakistan

Although large-scale manufacturing of automobiles is being done in the country, the market is extensively dominated by international companies that have set up their production facilities in Pakistan. The production cost of these companies, as compared to the local production, is significantly lower with more comfort and driving facilities. These companies have, however, started different PPP models with local producers. The luxury car fleet is, however, imported into the country with major brands operating within the country, as shown in the figure.

As opposed to the case of ICE cars, there are no manufacturers currently operating in Pakistan for electric cars and all ECs present in the country are imported (as of 2021). Some companies, including MG motors and Zia Electromotive have committed to start the business of low-cost electric cars shortly. Most of the components used for these cars will be manufactured locally by the existing OEMs while some EV specific parts will be imported. The key players for electric cars in Pakistan are also indicated in **Figure 13**. The EV fleet is, however, only for luxury cars where a single vehicle of Audi costs around PKR 20 million.

Key Players of Pakistan's Internal Combustion Engine Cars Industry		
Sr. No	Company Name	Relevant Web Link
1	Toyota	https://www.toyota-indus.com/
2	Suzuki	https://www.suzukipakistan.com/
3	Kia	https://kia-luckymotorcorp.com/
4	Hyundai	https://www.hyundai-nishat.com/
5	Honda	https://www.honda.com.pk/
6	MG	https://mgmotors.com.pk/
7	BAIC	https://www.sazgarbaic.com/
8	Proton	https://www.proton.com.pk/
9	FAW	https://alhajfaw.com/
10	DFSK	https://dfskpakistan.com/
11	United Cars	https://unitedcars.com.pk/

Key Players of EV Cars		
1	MG Motors	https://mgmotors.com.pk/MG-ZS-EV
2	Audi	https://www.audi.com.pk/sea/web/pk/models/tron/audi-e-tron.html
3	Zia Electromotive Pvt. Ltd	
Key Players of Pakistan's ICE HTVs & LTVs Industry		
1	Hino	https://www.hinopak.com/
2	ISUZU	https://gil.com.pk/
3	Nissan	https://ghandharanissan.com.pk/
4	Toyota	https://www.toyota-indus.com/
5	Hyundai	https://www.hyundai-nishat.com/
6	FAW	https://alhajfaw.com/
7	JW Forland	https://jwforland.com/
Key Players of Pakistan's EV HTVs & LTVs Industry		
1	VPL Pakistan Group	https://vpl.com.pk/
2	Sapphire	https://augaf.com/sapphire-to-build-electric-vehicles-manufacturing-plant/
Key Players of Pakistan's EV 2-wheeler Market		
1	Super Star	http://memonmotor.com/
2	Indus Motor Company Limited	https://www.linkedin.com/company/indus-motor-company-ltd/?originalSubdomain=pk
3	Jolta Electric	https://www.joltaelectric.com/
4	Sunra	https://www.sunraev.com/
5	Mega Electric	https://megabikes.pk/step-1-mega-bikes
6	Elite Auto Industries	https://www.facebook.com/Elitesawari/
7	Sazgar (Rickshaw)	https://sazgarautos.com/eve/

Figure 13 Key Players for ICE and Electric Vehicles in Pakistan

3.1.2. Market of Light and Heavy Transport Vehicles in Pakistan

The larger market of ICE HTVs and LTVs in Pakistan is local production from the international companies. The imported products are busses and large trucks. A complete electric fleet for this category does not exist, however, some PHEVs and BRTs are operating on electric mobility. Key players operating for both ICE and EVs are shown in the figure below. Further, as of now, no new company has committed to operate in Pakistan for manufacturing complete electric fleet for this category.

3.1.3. Two and Three-Wheeler Market

The 2-wheeler market is Pakistan's largest auto market with more than 100 companies and models present within the country. However, more than 99 percent of the market is dominated by motorbikes in the range of 70-150cc. The parts within these categories are well-standardized and interoperable as to allow for higher resale and low repair or maintenance cost. The designs are kept simple enough to ensure that the total capital as well as operating cost of these vehicles are as low as possible. Unlike 2-wheelers, 3-wheelers are a very small market that is used for both passengers and freight transport purpose. There are approximately 50 different manufacturers of 3-wheelers operating with very similar designs to ensure low cost and high inter-operability.

For electric 2-3 wheelers the market is underdeveloped (still far more than other categories) with some companies that have started local manufacturing. Like electric cars, luxury two wheelers are not being developed since only a single major player is operating in this area. Most of the battery packs are currently being imported, however, assembling of battery packs using Li-Ion cells is also happening on a small scale. Figure 13 represents the key players operating in the electric 2-3 wheeler market of Pakistan.

3.1.4. Market Progress on Charging Infrastructure and EV Components

The slow growth of EV stock as highlighted in the previous sections and the existing infrastructure for EVs are both interlinked features, with one limiting the growth of the other and vice versa. Just like EVs are not being fast paced due to lack of infrastructure, similarly, the infrastructure investments are not coming in due to lack of vehicle stock available in the country. Since charging stations are not available locally, the current CAPEX and OPEX are significantly high. A single fast charger costs approximately $20,000 and, hence as of now, there are only a few fast-charging stations in the country. On the manufacturing front, there are no OEMs present in Pakistan that are offering technical solutions for EV manufacturing. Currently, three key players that are engaged in Infrastructure development are Tesla Industries, MAQ International and Adaptive Technologies. The battery segment is mainly being developed by Zoxcell, Adaptive Technologies, Baraq Box, and Fuel Motion Inc.

3.1.5. The Untapped Future Market Potential of Electric Vehicles in Pakistan

A critical review of the current market status indicated above highlights that unless the government takes an initiative to convert the BRTs or public vehicles to electric, the first transformation that would happen in Pakistan's EV landscape would be for the 2-wheelers. The market spread, however, needs to follow the same trend as was being followed by ICE-based 2-wheelers that ensures a simple design with high interchangeability. This would lead to a low-cost EV product that can also be integrated on the same ICE-based vehicle parts.

For 3-wheelers, the market for Pakistan is limited to only short-range transportation in some areas of the country. The most critical need for development of the EV market is in the 4-wheeler industry as given the constantly rising fuel prices in Pakistan, the demand for e-mobility will increase. A lot of companies have committed to establishing locally-built units. Although compared to ICE cars, the driving range might pose challenges, however, the fast-charging stations which many companies have committed could be the game changer. For HTVs, the indigenous production will remain neglected since no new player has shown any support for indigenous development. The market will most probably be dominated by imported vehicles.

3.2. The Total Cost of Ownership of EVs in Pakistan

As discussed in the previous sections, the capital cost of EVs is much higher than then the corresponding ICE vehicles with the same performance metrics. However, even as of today, the operating cost of EVs is much lower than ICEs. The total cost of ownership, therefore, combines all the cost factors associated with a vehicle during its whole lifetime. To developers and policy makers, this provides the developers and policy makers with a much better idea of designing the supporting infrastructure while to consumers it can significantly support their purchase decisions.

While the TCO calculations have been calculated in the study conducted by NEECA on e-mobility, the values shown here represent the updated calculations based on the revised values of petroleum products and power tariffs in Pakistan. TCO for various categories of EVs are presented in **Figure 14.**

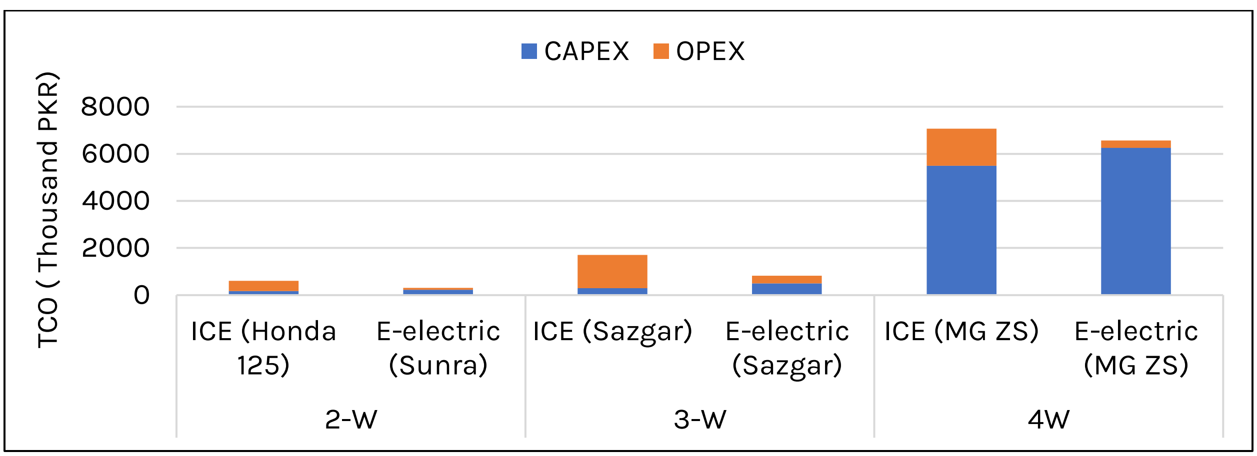


Figure 14 Total Cost of Ownership of Electric & ICE Vehicles in Pakistan[2]

[2] These estimates are done by the authors of study. However, a similar analysis was also conducted in a study conducted by the World Bank using the year 2020 data.

The figure above clearly indicates that while EVs have a higher purchase cost, their total ownership cost is still below the ICE-based vehicles. Following insights can be generated from figure 14.

1. The capital cost of Electric 2-wheelers is 41 percent higher than the counter ICE, however, the TCO for a 5-year period of Electric 2-wheeler is almost 49 percent less than the ICE counterpart.
2. The capital cost of electric 3-wheeler is almost 50 percent higher than the counterpart ICE, however, the TCO for electric 3-wheeler is almost 52 percent less than the ICE counterpart.
3. The capital cost of electric car is almost 10 percent higher than the ICE counterpart, however, the TCO for electric car is about 7 percent less than its ICE counterpart.

A comparative assessment of these figures with the study conducted by NEECA further indicates that the cost differentials between both are also increasing and the TCO of EVs is becoming much less than the ICE with an increase in the petroleum prices.

Box 3: People's Willingness to Purchase EVs in Pakistan: A Case Study in Lahore

This case study was conducted to determine the key influencing parameters that control behavioral nature of the common citizens to purchase electric vehicles in Pakistan. The case study was conducted in Lahore through an online questionnaire for both men and women.

The study indicated that people are willing to adopt the mitigation measures to control climate change and they do recognize EVs as an essential component to reduce GHG emissions. However, at the same time people also expect the same performance and social influence from the EVs.

Since the infrastructure is not currently available to facilitate the daily usage of EVs, most people are currently unwilling to purchase it. This, however, indicates a strong possibility of a future shift towards EVs at a large scale.

4. CHAPTER 4: SOCIO-ECONOMIC ASSESSMENT OF EV PENETRATION

This section describes a modeling study conducted to analyze the socioeconomics of electric vehicles in Pakistan under the broader scope of National Electric Vehicle Policy 2019. A Low Emission Analysis Platform (LEAP)[3] model has been designed for the whole transport sector, driven under different scenarios of EV penetration. The core objectives of the model include:

- To analyze the energy, economic, and environmental profiles under different scenarios of EV penetration
- To analyze the fuel switching from the increasing demand of electricity and reducing demand of imported oil and gas

4.1. Model Development & Data Collection

The model development uses a bottom-up approach where the total energy demand in a particular year is calculated by cumulating the fuel demand from each single unit of vehicle technology. Key steps involved in the modeling process are as defined in the Figure 15. Model interface, structure and segregations is attached as **Annexure 2.**

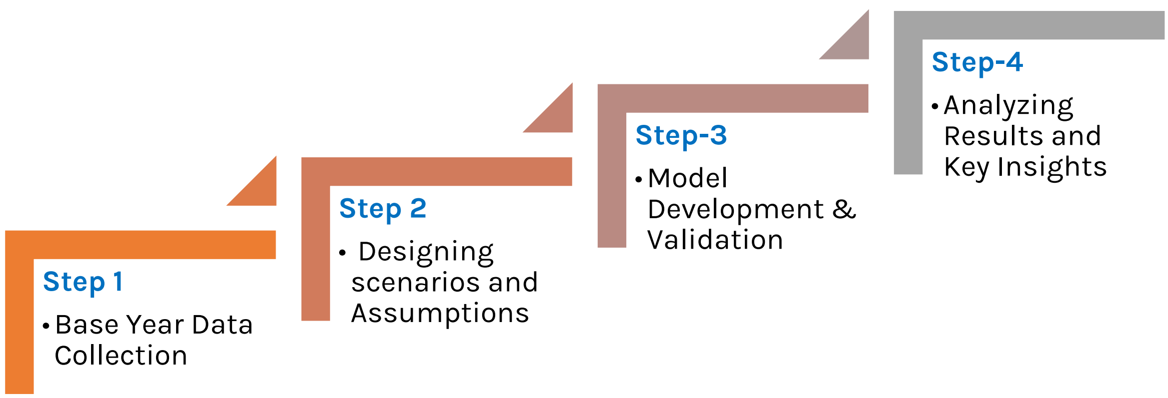


Figure 15 Model Development Process

4.1.1. Base Year Data Collection

The major data inputs for the base year include:

- Vehicle stock of different technologies, such as 2-wheelers, 3-wheelers, 4-wheelers, busses, trucks, etc.
- Vehicle mileage of each technology
- Share of different fuels within each technology

[3] https://www.sei.org/projects-and-tools/tools/leap-long-range-energy-alternatives-planning-system/

- Average annual travel (km) for each category/technology
- Load factor for each category/technology
- Energy intensity of each category/technology
- Emission factors for each category/technology
- CAPEX and OPEX for each category/technology

The above-mentioned data parameters for base year are collected for categories as depicted in the table while the detailed data sets are attached as **Annexure 3.**

Table 4: Sub Categorization of Vehicle Categories and their Running Fuels for the base year

Category	Mode of Transport	Vehicle Type	Running Fuels
Passenger Transport	Road Transport	2-wheelers 3-Wheelers	Gasoline, CNG, Electric
		Cars and SUVs	Gasoline, CNG, Electric, Diesel
		Taxis	Gasoline, CNG
		Mini and Large Buses	CNG, Gasoline, Diesel.
		Tractors	Diesel
	Rail Transport	Rails	Diesel
	Air Transport	Airflights	Aviation Fuel
Freight Transport	Road Transport	Trucks	Diesel
		Freight Vans	Diesel & Gasoline
	Rail Transport	Rails	Diesel
	Air Transport	Air flights	Aviation Fuel

Further, the model setup before defining the scenarios include base year (2020), end year (2040) and defining the total number of scenarios that will be created (can be changed later). Key assumptions in the model may be defined either before or after designing the base year. This depends entirely on the mathematical approach where the base year data may also be calculated or driven through the key assumptions. Key assumptions used in this study include i) fuel economy increase, ii) passenger km elasticity, iii) car ownership per km, iv) elasticity of car ownership, and v) public elasticity. For freight transport, it also includes tonnage capacities of each category.

4.1.2. Modeling Equations

The key modeling equations used for calculations of base year as well as for projected years are depicted in the table.

Freight Transport

$$\mathbf{ECFT(i) = TKFT * SFTM(i) * EIFT(i)}$$

Where $ECFT(i)$ (Final energy demand for transport mode i) is calculated as a function of:

- TKFT: activity (amount of goods transported) 10^9 t-km
- SFTM(i): Share of the transport mode i
- EIFT(i): Energy intensity of transport mode i (efficiency), calculated as: final energy (in energy units) / 100 t-km

$$\mathbf{TKFT = CKFT + \sum_{i=Econ\ Sect} CTKFT(i) * VA(i)}$$

Where CKFT is the curve intercept, CKFT (i) is the slope, and VA (i) is the main driving factor (either GDP or income growth).

Passenger Transport

Passenger transport in the model can be calculated as

$$\mathbf{PKU = DU * 365 * VS}$$

where,

- PKU gives the overall activity (Passenger km)
- DU gives the daily activity
- VS gives the vehicle stock

If there are similar transport modes that use different fuels (for example, cars using gasoline, diesel or electricity), each of these needs to be defined as a separate transport mode so that the fuel amount can be accounted for properly. This can be calculated through

$$\mathbf{PKUTM(j) = PKU * SUMT(j)}$$

where,

- PKUTM (j) gives activity of that mode
- PKU gives the total activity
- SUMT(j) gives the share of that mode.

Total Energy Demand

The final energy demand from the sector can then be summarized through

$$\mathbf{EDij = NVij * VKTij * FEij}$$

where,

ED-Energy Demand; NV-Number of Vehicles; VKT-Vehicle Kilometer Travel; FE-Fuel Economy; and the terms i,j represent the type of vehicles (i for ICE and e for EV).

Total Cost Estimates

For cost estimates,

$$TCij = NVij * VKTij * FEij * FCij$$

Where TC is the Total Cost; FC-Fuel Cost, while others are the same as defined above.

Total emission Estimates

$$Ev.Di = NV\ i * VKT\ i * FEi * Eli$$

where,

Ev.D-Environmental Demand & EL is Environmental Loading.

4.1.3. Scenario Development

To further project the energy, economic and environmental profiles, three different scenarios have been developed, each representing a different policy story line. The main difference between each scenario is either in the economic growth or the penetration rates of electric or hybrid vehicles. The key details of each scenario used in the study are as described in Table 5.

Table 5 Description of LEAP Modeling Scenarios

Scenario Description	Scenario Representation	Scenario Details
Business as Usual	S-BAU	Under this scenario, the transport sector of Pakistan continues to grow with the similar share in stock of vehicles as in year 2022. The scenario is designed to act as a reference to analyze the cost Pakistan would have to bear if it does not make the required transition.
Electric Vehicle Policy Scenario	S-EPS	This scenario follows the trajectory as prescribed under Pakistan's National Electric Vehicle Policy 2019 where category achieves the desired share by 2030 and 2040. However, as indicated under the NEVP, the share of hybrid vehicles will remain extremely low.
Slow Growth Scenario	S-SGS	This scenario represents the growth of transport sector very similar to the business-as-usual

		scenario till 2025, however, the EVs start growing after 2025 and eventually achieving a share of 10% sales by 2030 and 25% by 2040. The Hybrid electric vehicles in this scenario however grow with a much higher pace as compared to EVs in the near run.
Energy Transition Scenario	S-ENE	This scenario models interventions in the transport sector beyond just the penetration of electric vehicles to the use of mass transit systems, improvements in fuel efficiency, and the freight shift towards the Rail transport. This scenario has been benchmarked with the IEA energy transition scenario for the transport sector.

4.2. Results and Discussion

This section describes the ENE-ECO-ENV impacts of the electric vehicles under different scenarios as described in the previous section. The results would be covered under three main sections, i.e. the impact on energy and fuel consumption, the impact on cost of travel, and the impact on environment.

4.2.1. Total Energy Demand Profiles

Consumption under different transport categories

Figure 16 indicates Pakistan's projected energy demand and use of different fuels in the transport sector for different categories of travelling.

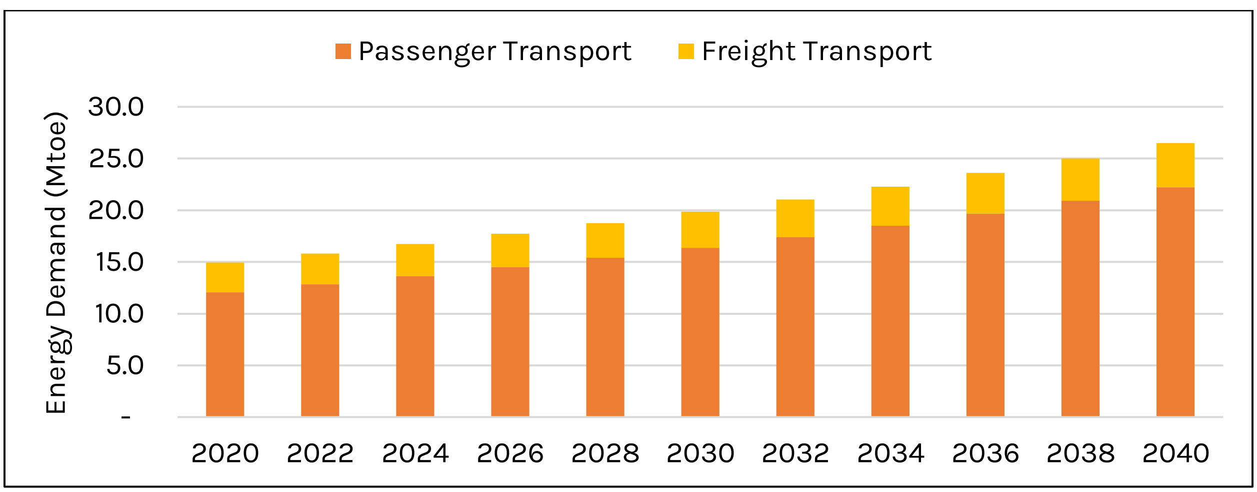


Figure 16 Energy Consumption under Passenger and Freight transport sectors of Pakistan

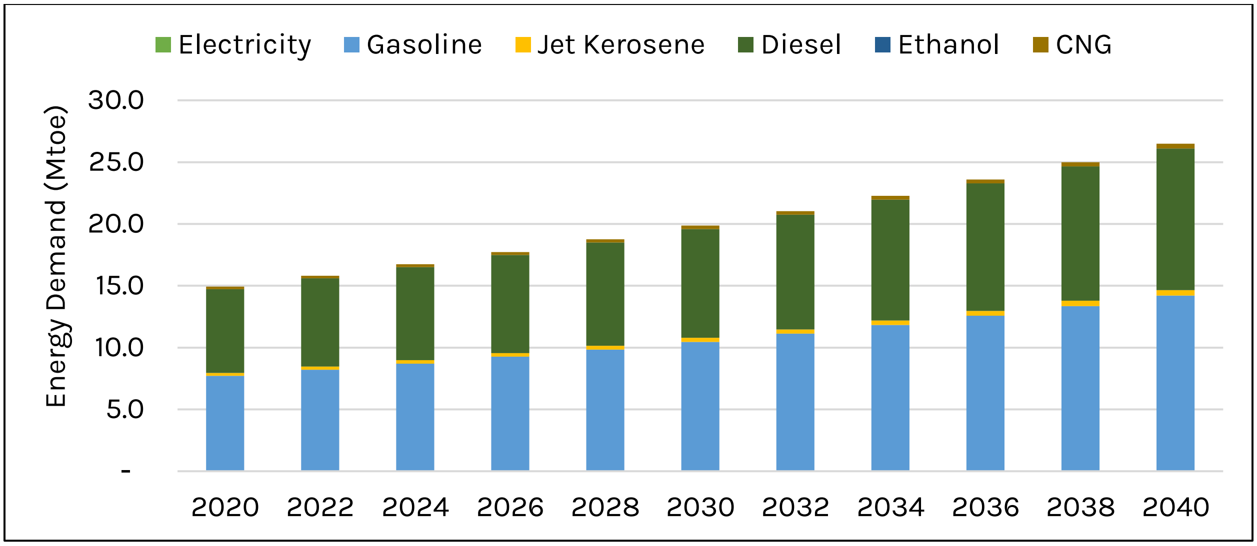


Figure 17 a) Energy Consumption under main categories b) Energy Consumption through different fuels.

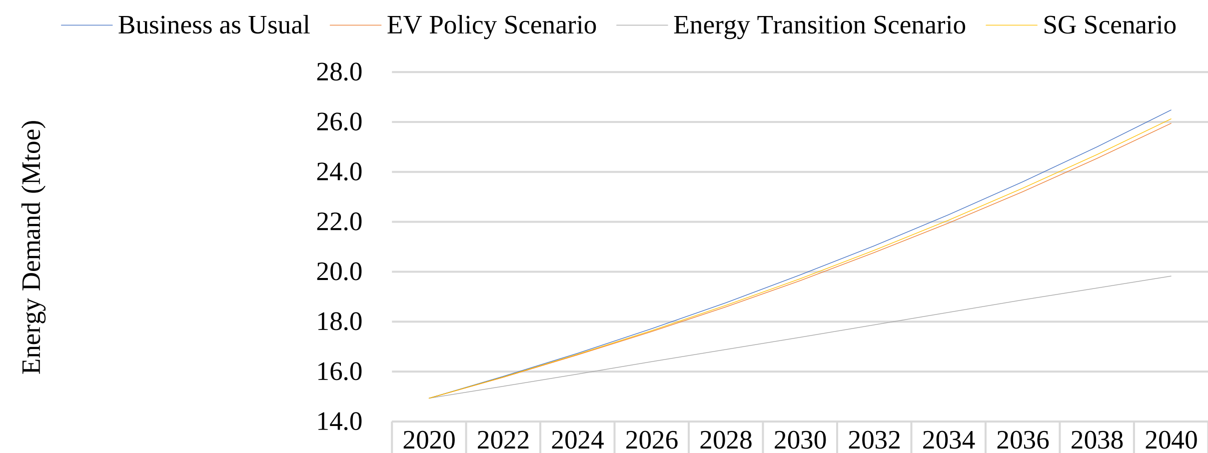
Following key insights can be obtained from Figure 16 & 17.

- In 2020, the total energy demand of Pakistan's transport sector was around 15 Mtoe. By 2030 and 2040, this value could increase to 20 Mtoe and 27 Mtoe respectively, indicating acompound annual growth rate of 2.91 per cent & 2.98 per cent.
- In 2020, the passenger transport constitutes the major share of around 81.2 percent (12.1 Mtoe). Under the business-as-usual (BAU) scenario, this share is further expected to increase to 82.4 per cent by 2030 and 83.7 per cent by 2040. This is linked to a higher growth of passenger travel as compared to the growth in freight transport.
- In terms of fuel share, gasoline currently constitutes the largest share of approximately 51.67 per cent, followed by Diesel (45.6 percent) and then CNG & Jet Kerosene (2.73 per cent). Under BAU scenario, by 2030, gasoline consumption of the transport sector would be 52.76 per cent (10.5 Mtoe), followed by Diesel share of 44.2 per cent (8.8 Mtoe), CNG & Jet Kerosene share of approximately 3 per cent (0.6 Mtoe). By 2040, these shares would increase to 53.5 per cent, 43.4 per cent, and 3.4 per cent respectively.
- These statistics indicate that under the BAU scenario, the energy demand of the transport sector will remain highly dominated by the fossil fuels. Since the larger portion of these fuels are imported, it would significantly add to the import cost and fiscal burden on the transport sector.

Each of the main categories highlighted in the figure above are sub-categorized into different vehicle types. Projections of these categories under BAU scenario are attached in the **Annexure 4.** However, the key highlights from these figures are as described below:

- Among all categories, the passenger road transport sector consumes the largest of energy. In 2020, this value was around 11.3 Mtoe and under the BAU scenario, it is expected to increase to 15.3 Mtoe by 2030 and 20.8 Mtoe by 2040. The largest demand of energy in this sector is coming from the 2-Wheelers (3.76 Mtoe in 2020, 5.1 Mtoe in 2030 and 7 Mtoe in 2040) followed by Passenger Cars (2.2 Mtoe in 2020, 3.1 Mtoe in 2030 and 4.2 Mtoe in 2040). In the context of fuel share, gasoline is the main constituent with a percentage share of 68.1 percent-70 percent across the modeling horizon.
- In comparison to road transport, passenger rail constitutes a very minute share of 485 ktoe in 2020. Even by 2030 & 2040, this value is expected to reach 658 ktoe and 900 ktoe, respectively. This, however, only has diesel use as its only fuel.
- The air transport currently consumes around 247 ktoe which is expected to reach 345 ktoe by 2030 and 455 ktoe by 2040. Jet kerosene is the only fuel being used in this sector.
- Freight transport is also dominated by the road network consuming around 2.4 Mtoe in 2020 (85% share in toral freight transport), 3 Mtoe in 2030 and 3.7 Mtoe in 2040. Rail freight transport occupies a very minute share of 432 ktoe in 2020, 526 ktoe in 2030, and 642 ktoe in 2040. In context of fuel consumption, both road and rail transport are completely based on diesel with negligible contribution from other fuel sources.
- The road freight transport has two main categories for transferring goods, i.e., trucks and freight vans. Trucks consumed around 1.9 Mtoe of energy in 2020 which is expected to increase to 2.39 Mtoe in 2030 and 3 Mtoe by 2040. Freight vans constitute a comparatively smaller portion with 461 ktoe of energy consumed in 2020 which is projected to increase to 570 ktoe by 2030 and 685 ktoe by 2040.

While the above-mentioned figures highlight the share of different vehicle type and their fuel consumption, it also indicates that under the BAU scenario, the share of EVs and electricity as the transport fuel is non-existent. With penetration of electric vehicles under different scenarios, the above-mentioned energy consumption profiles would change as shown in **Figure 18.**



	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
Business as Usual	14.9	15.8	16.7	17.7	18.8	19.9	21.0	22.3	23.6	25.0	26.5
EV Policy Scenario	14.9	15.8	16.7	17.6	18.6	19.6	20.8	22.0	23.2	24.5	25.9
Energy Transition Scenario	14.9	15.4	15.9	16.4	16.9	17.4	17.9	18.4	18.9	19.4	19.8
SG Scenario	14.9	15.8	16.7	17.6	18.7	19.7	20.9	22.1	23.3	24.7	26.1

Figure 18 Energy Demand Under Different Scenarios of EV Penetration

Figure 18 highlights how penetration of Electric vehicles can alter the energy demand profile of Pakistan. Key insights which can be obtained from this figure are as described below:

- Under different scenario, the energy demand from the transport sector of Pakistan in 2030 could vary between 20 Mtoe (high-end) and 17.4 Mtoe (low-end). By 2040, these could further vary between 27 Mtoe and 19.8 Mtoe.
- The BAU scenario represents the highest energy demand by 2040 with an ACGR of 2.92 percent. For EPS, SGS, and ETS, this ACGR will be 2.8 percent, 2.84 percent, and 1.43 percent respectively.
- The EV policy scenario indicates that through penetration of EV as per the EV policy 2019 targets, Pakistan can cumulatively save around 2 Mtoe of energy by 2030 and 5 Mtoe of energy by 2040. This links to the low energy requirements of the electric vehicles. Further, by 2030 and 2040, the overall demand of the transport sector would be around 0.3 Mtoe and 0.7 Mtoe less than the BAU scenario.
- In slow growth EV scenario (EV sales of 20% by 2030), the cumulative energy savings by 2030 and 2040 is limited to 0.7 Mtoe and 3.3 Mtoe respectively. By 2030 and 2040, the annual energy demand would be 0.2 Mtoe and 0.4 Mtoe less than the corresponding value in BAU scenario.
- The energy transition scenario indicates a much larger impact through improvements in fuel efficiency, mass transit systems, and a rapid shift of freight towards rail transport. Under ENE, the cumulative energy savings till

2030 and 2040 are 12.5 Mtoe and 58.7 Mtoe respectively. On the annual basis, the total annual demand of the transport sector by 2030 and 2040 would be 2.5 Mtoe and 6.3 Mtoe lower than the BAU scenario.

Increase in Use of Electricity

The most critical way the penetration of EVs would alter the landscape of energy consumption in transport is through the requirements of electricity. Figure 19 describes the use of electric vehicles under different scenarios and the increased requirement of electricity in the transport sector.

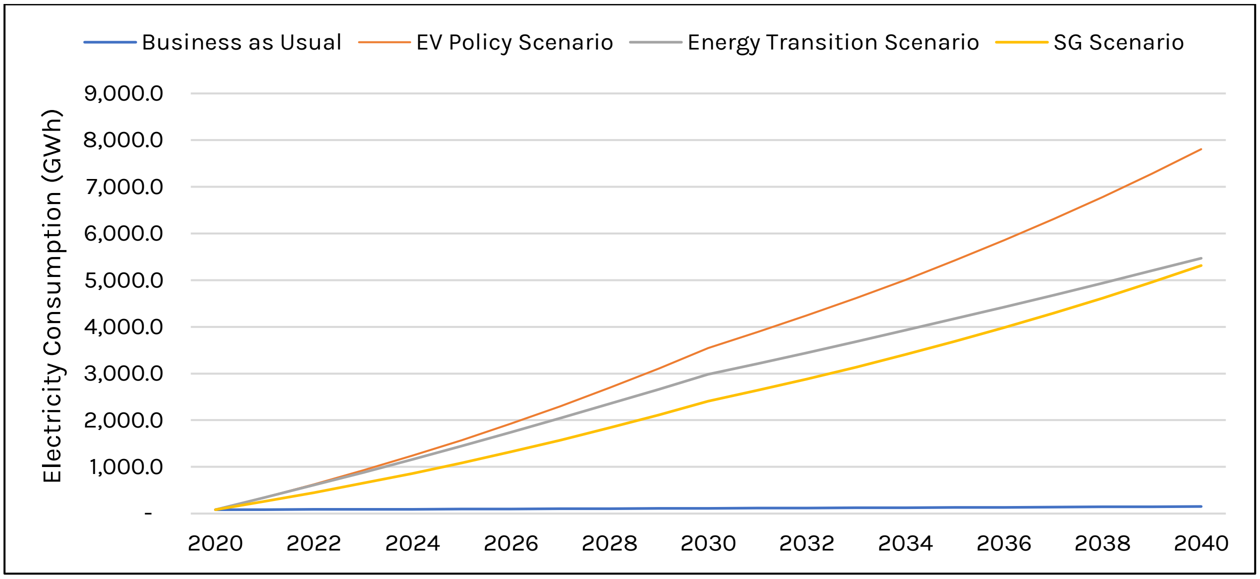


Figure 19 Increase in use of electricity under difference scenarios

Following key insights can be obtained from the Figure 19.

- In the BAU scenario, electricity consumption is negligible due to a very minute share of EVs in the mix. The current stock of EVs available in the country consumes a maximum of 80 GWh. By 2030 and 2040, this value would reach a maximum of 115 GWh and 152 GWh respectively.
- In the EV policy scenario, the transport sector consumption of electricity would reach 3351 GWh and 7331 GWh by 2030 and 2040, respectively. This indicates electricity consumption increase with ACGR of 45 percent and 25.3 percent respectively. Thus, to achieve the targets of EV policy, Pakistan would have to manage an increased electricity load of around 3351 GWh by 2030.
- In the slow-growth EV scenario, the transport sector would require 2212 GWh and 4838 GWh by 2030 and 2040, respectively. This indicates the ACGR of 38 percent and 22.7 percent by 2030 and 2040 respectively.
- In the Energy transition scenario, the EV sales share is same as that in the EV policy scenario, however, due to lower travelling requirement driven by a shift

from road to rail transport, the electricity requirements by 2030 and 2040 are limited to 2818 GWh and 5135 GWh respectively.

While the overall electricity consumption values are defined in the above-mentioned statistics, the sub-sectoral share of these values is further highlighted in **Annexure 5**.

Reduction in Consumption of Gasoline and Diesel

With the increase in electricity consumption, the requirement of diesel and gasoline will drop with an increase in penetration of electric vehicles. **Table 6** indicates the change in gasoline consumption for different scenarios in comparison to Business as Usual (negative sign indicates a decrease).

Table 6 Change in Consumption of Gasoline under different scenarios

Scenario	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
EV Policy Scenario	0.00	-0.05	-0.11	-0.17	-0.24	-0.32	-0.39	-0.47	-0.55	-0.64	-0.74
Energy Transition Scenario	0.00	-0.30	-0.63	-0.99	-1.39	-1.83	-2.29	-2.80	-3.35	-3.95	-4.60
SG Scenario	0.00	-0.03	-0.07	-0.11	-0.15	-0.21	-0.25	-0.30	-0.35	-0.41	-0.48

Similarly, **Table 7** indicates the change in Diesel consumption for different scenarios in comparison to the Business as Usual.

Table 7 Change in Consumption of Diesel under different scenarios

Scenario	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
EV Policy Scenario	0.00	-0.03	-0.06	-0.09	-0.13	-0.18	-0.21	-0.25	-.29	-0.3	-0.4
Energy Transition Scenario	0.00	-0.17	-0.37	-0.58	-0.83	-1.10	-1.39	-1.71	-2.0	-2.4	-2.9
SG Scenario	0.00	-0.02	-0.04	-0.07	-0.09	-0.12	-0.15	-0.18	-0.2	-0.2	-0.3

Following key insights can be obtained from Table 6 and Table 7

- In EPS, the annual consumption of gasoline and diesel by 2030 would be -0.32 and -0.18 Mtoe lower than the BAU scenario. This also indicates a cumulative Diesel savings of around 1 Mtoe by 2030 and 4 Mtoe by 2040. For gasoline, these cumulative savings are 1.6 Mtoe and 7 Mtoe by 2030 and 2040, respectively.

- In ETS, the annual consumption of gasoline and diesel would be -1.83 and -1.10 Mtoe lower than the BAU scenario. This also indicates a cumulative gasoline savings of around 9.4 Mtoe by 2030 and 42 Mtoe by 2040. For diesel, these values are 5.5 Mtoe and 25.6 Mtoe by 2030 and 2040, respectively.
- In SGS, the annual consumption of gasoline and diesel would be -0.21 and -0.12 Mtoe lower than the BAU scenario. This also indicates a cumulative gasoline savings of around 1 Mtoe by 2030 and 5.37 Mtoe by 2040. For diesel these values are 0.6 Mtoe and 3.1 Mtoe by 2030 and 2040, respectively.

4.2.2. Transport Sector Economics under Different Scenarios

This section describes the impact of electric vehicles on the economic profile of the transport sector. The associated costs are mainly associated with the running cost of different categories of the vehicle as indicated in Table 8. This highlights the total running cost for various categories of vehicles under the BAU scenario.

Table 8 The running cost ($ million) of various categories of vehicles under the BAU scenario

Passenger Road Transport											
Branch	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**	**2036**	**2038**	**2040**
Passenger Cars	1,765	1,876	1,994	2,119	2,253	2,395	2,546	2,706	2,876	3,057	3,250
Motorbikes	3,043	3,234	3,438	3,654	3,884	4,129	4,389	4,665	4,959	5,271	5,603
3-Wheelers	1,105	1,174	1,248	1,327	1,410	1,499	1,594	1,694	1,801	1,914	2,035
Taxis	379	403	429	456	484	515	547	582	618	657	699
Buses	1,426	1,516	1,611	1,713	1,821	1,935	2,057	2,187	2,324	2,471	2,626
Minibuses	10	10	11	12	12	13	14	15	16	17	18
Tractors	68	72	77	82	87	92	98	104	111	118	125
Others	4,673	4,967	5,280	5,613	5,966	6,342	6,741	7,165	7,617	8,096	8,606
Total	12,468	13,254	14,088	14,975	15,918	16,920	17,985	19,118	20,321	21,601	22,961
Passenger Rail Transport											
Branch	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**	**2036**	**2038**	**2040**
Diesel	288	307	326	346	368	391	416	442	470	500	531
Electricity	0	0	0	0	0	0	0	0	0	0	0
Total	288	307	326	346	368	391	416	442	470	500	531

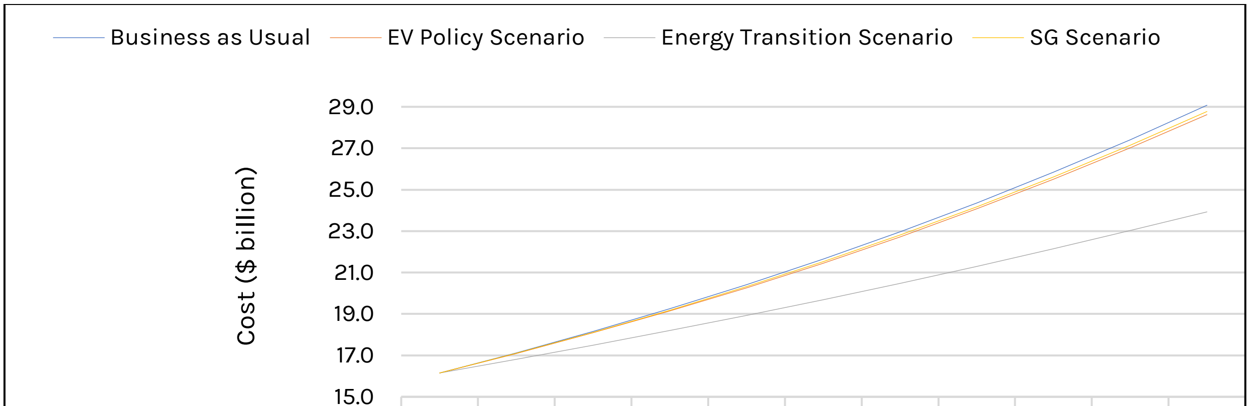
Passenger Air Travel											
Branch	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**	**2036**	**2038**	**2040**
Aviation Fuel	1534	1631	1734	1843	1959	2082	2213	2352	2501	2658	2825
Total	1534	1631	1734	1843	1959	2082	2213	2352	2501	2658	2825
Freight Road Transport											
Branch	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**	**2036**	**2038**	**2040**
Trucks	1439	1497	1557	1620	1686	1754	1825	1898	1975	2055	2138
Freight Vans	337	351	365	380	395	411	428	445	463	482	501
Total	1776	1848	1922	2000	2081	2165	2252	2343	2438	2537	2639
Freight Rail Transport											
Branch	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**	**2036**	**2038**	**2040**
Diesel	82	85	88	92	96	99	103	108	112	116	121
Electricity	0	0	0	0	0	0	0	0	0	0	0
Total	82	85	88	92	96	99	103	108	112	116	121

The following key insights can be obtained from **Table 8:**

- In 2020, the total running cost of all categories combined come to around $16.1 billion. Under the BAU scenario, this value is expected to increase beyond $21 billion by 2030 and $29 billion by 2030.
- The maximum share of the running cost is coming from the passenger transport ($14.3 billion) i.e., 88.8 percent while freight constitutes a share of 11.8 percent ($1.9 billion). By 2030 and 2040, the share from passenger transport is further expected to increase, up to 89.3 percent and 90.3 percent, respectively.
- In the passenger transport, road services currently occupy the largest share of around 87 percent. By 2030 and 2040, this value is expected to further increase to 87.3 percent and 87.5 percent, respectively.
- The sub-categories (i.e., 2-W, 3-W, cars, etc.) mirror the same trend as that of the energy demand described in the previous section.

Cost Trend Under Different Scenarios

The impact of electric vehicles on the cost profiles is driven by the low cost of travelling through EVs and comparatively low cost of electricity to drive a unit distance as compared to gasoline and diesel. **Figure 20** represents the cost profiles under different scenarios of EV penetration.



	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
Business as Usual	16.1	17.1	18.2	19.3	20.4	21.7	23.0	24.4	25.8	27.4	29.1
EV Policy Scenario	16.1	17.1	18.1	19.1	20.3	21.5	22.7	24.1	25.5	27.0	28.6
Energy Transition Scenario	16.1	16.8	17.5	18.2	18.9	19.7	20.5	21.3	22.1	23.0	23.9
SG Scenario	16.1	17.1	18.1	19.2	20.3	21.5	22.8	24.2	25.6	27.1	28.8

Figure 20 Total Running Cost of the Transport Sector Under Different Scenarios

The following key insights can be obtained from **Figure 20**

- In the EV policy scenario, the running cost in 2030 and 2040 has increased to $21.5 billion and $28.6 billion, respectively. As compared to BAU, this represents a decrease of $0.2 billion and $0.5 billion in respective years. Further, it indicates that through penetration of EVs as per the policy, there is a potential to save approximately $1200 million by 2030 and $4300 million by 2040.
- In a slow growth scenario, the running cost in 2030 and 2040 has increased to $21.6 billion and $28.8 billion, respectively. As compared to BAU, this represents a decrease in $0.1 billion and $0.3 billion in respective years. Further, it indicates that through penetration of EVs (as per this scenario), there is a potential to save approximately $900 million by 2030 and $2900 million by 2040.
- Since cost savings are an index to energy savings, the highest percentage of cost savings is achieved in the energy transition scenario. By 2030 and 2040, the cost in ENE has increased to $19.7 billion and $23.9 billion respectively. This is significantly lower than the corresponding values in $21.7 billion and $29.1 billion in BAU for the respective years. In this scenario, the cumulative savings increase to around $10,200 million by 2030 and $45,900 billion by 2040.

While the overall cost trend has been identified in the last section, the cost trend for various transport sub-sectors under different scenarios is also identified in **Figure 21-Figure 23**.

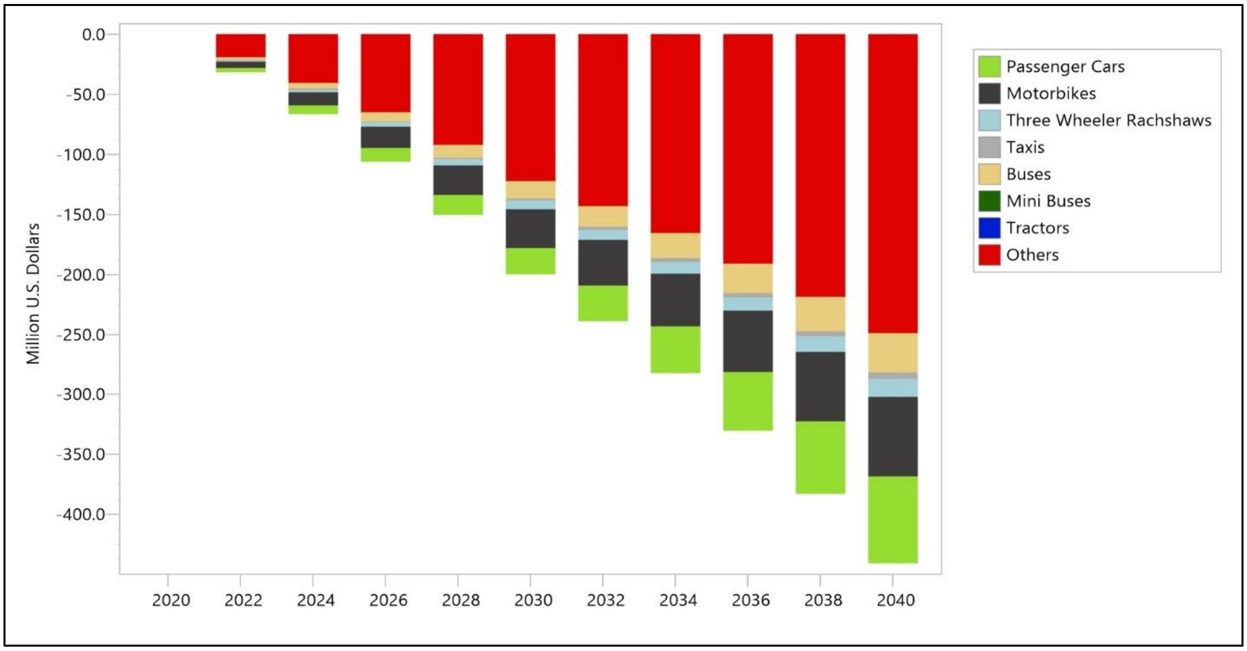


Figure 21 Relative Cost Decline for Different Transport Sub-sectors in EPS

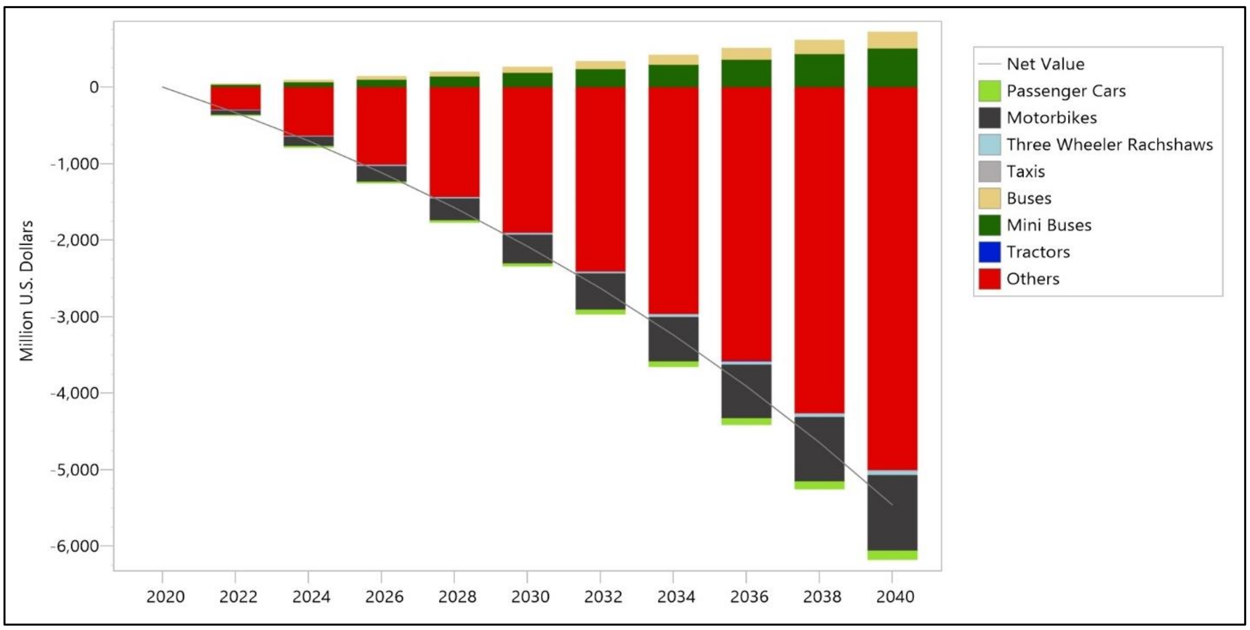


Figure 22 Relative Cost Decline for Different Transport Sub-sectors in ENE

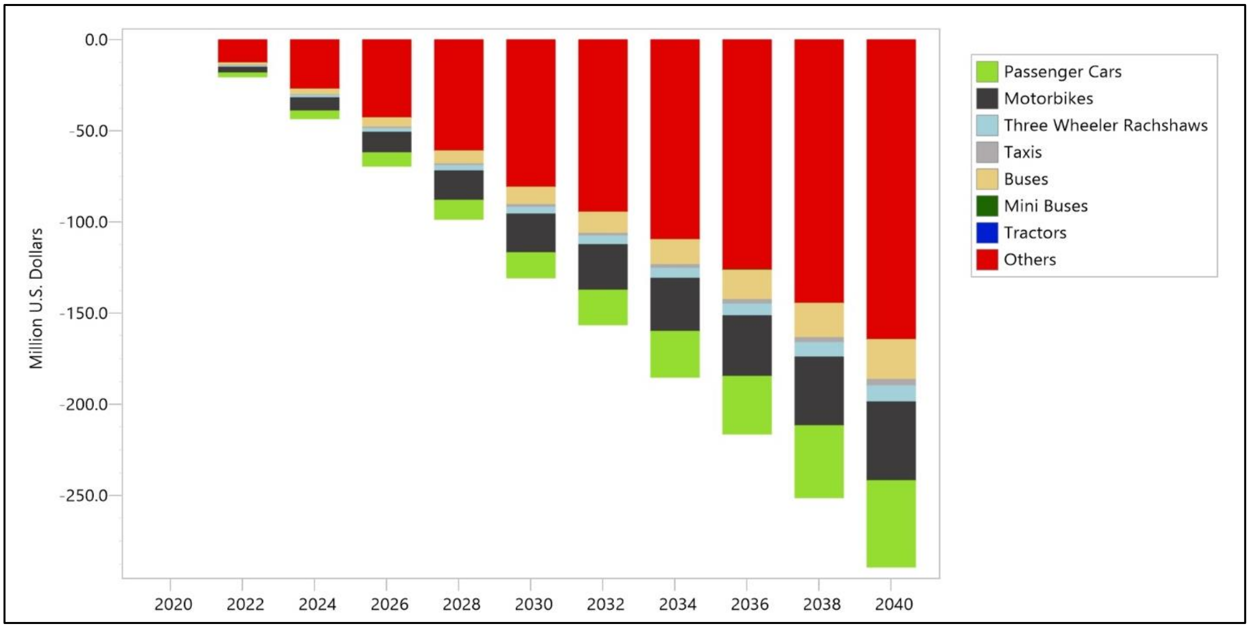


Figure 23 Relative Cost Decline for Different Transport Sub-sectors in SGS

4.2.3. Transport Sector Environment Profiles

This section describes the impact of electric vehicles on tail-end emissions from the transport sector. While each fossil fuel has an environmental loading factor, the emissions from EVs are zero. The emissions resulting from the generation of electricity required for running EVs are not directly incorporated in the model.

Figure 24 represents the overall emissions resulting from the transport sector, sub-categorized into its two main sub-categories, i.e., passenger and freight.

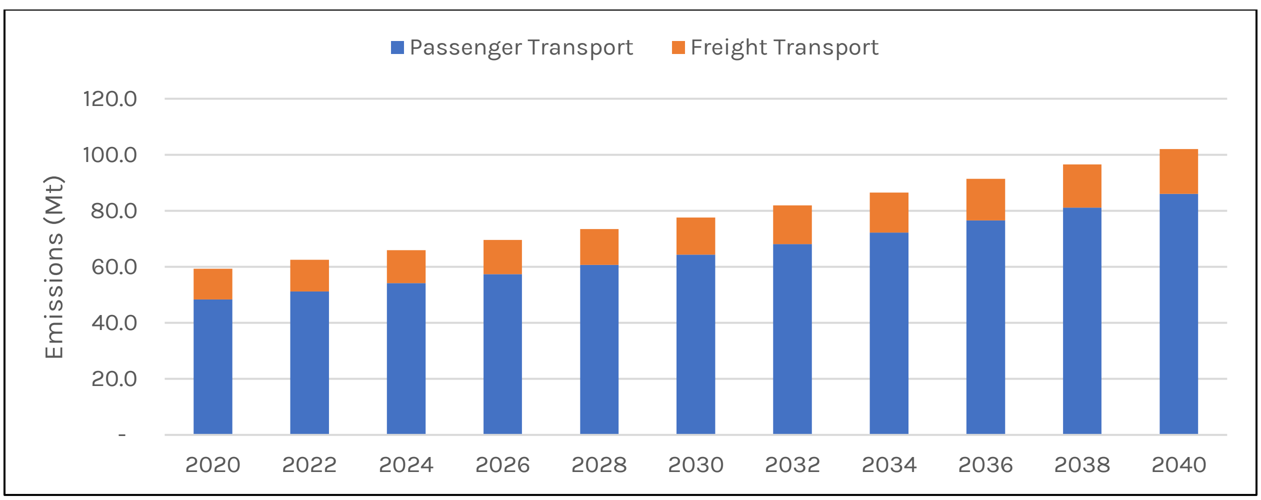
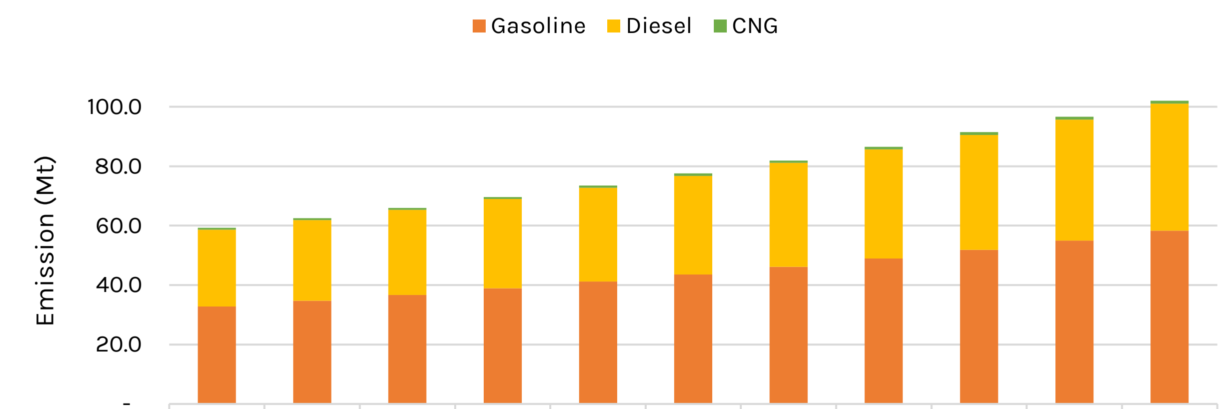


Figure 24 Emissions from the Transport Sector Under the BAU Scenario

The transport sector of Pakistan currently emits around 59 Mt of CO2 emissions. By 2030 and 2040 under the BAU, this value is expected to reach around 77.5 Mt and 102.1 Mt, respectively. This indicates an ACGR of 2.76 percent. The share of these emissions from different fuels are as indicated in Figure 25.



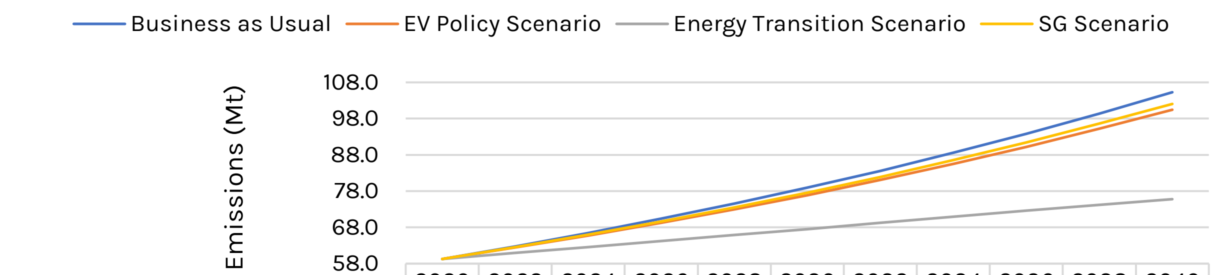
	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
CNG	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0
Diesel	25.9	27.2	28.6	30.1	31.6	33.2	34.9	36.7	38.6	40.7	42.8
Gasoline	32.8	34.7	36.7	38.9	41.2	43.6	46.2	49.0	51.9	55.0	58.3

Figure 25 Emissions from Different Fuel Types in the BAU Scenario

Figure 25 indicates that currently the largest share of emissions from the transport sector of Pakistan is coming through the burning of gasoline (55.3 percent) followed by Diesel (43.67 percent). By 2030 and 2040, the share of emissions from gasoline will be further increased to around 56.25 percent and 57 percent in the respective years. For different categories within the passenger and freight transport, the emissions values are described in **Annexure 6**.

Transport Sector Emissions Under Different Scenarios

Emissions from the transport sector also mirror the trend of energy demand and running costs. With penetration of EVs, the resulting emissions also decrease as shown in **Figure 26.**



	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
Business as Usual	59.3	62.8	66.5	70.4	74.5	78.9	83.6	88.6	93.8	99.4	105.3
EV Policy Scenario	59.3	62.4	65.8	69.3	72.9	76.8	81.1	85.5	90.2	95.2	100.4
Energy Transition Scenario	59.3	60.9	62.6	64.2	65.9	67.5	69.2	70.9	72.6	74.2	75.8
SG Scenario	59.3	62.5	66.0	69.6	73.5	77.5	81.9	86.5	91.4	96.6	102.1

Figure 26 Transport Sector Emissions Under Different Scenarios

Following insights can be obtained from Figure 26

- In EPS, total emissions from the transport sector would increase from 59.3 Mt in 2020 to 76.8 Mt in 2030 and 100.4 Mt in 2040. These emissions are 2.1 Mt and 4.9 Mt lower than the corresponding values in the BAU scenario. This indicates that fulfilling commitments under the EV policy can lead to cumulative emissions reductions of around 24 Mt.
- In SGS, the total emissions by 2030 and 2040 would increase to 77.5 Mt and 102. Mt, respectively. Under this scenario, the penetration of EVs can cumulatively reduce emissions of 16 Mt.
- The ENE scenario indicates the least emissions due to the cumulative impact of the transition to EVs, shift of freight transport to rail and a transition to mass transit system. The emissions in this scenario by 2030 and 2040 would increase to 67.5 Mt and 75.8 Mt, respectively. Cumulatively, this indicates the highest emission reduction potential of 139.6 Mt.

While the cumulative impacts are given in the above-mentioned statistics, the emission reduction in different categories due to penetration of EVs are shown in **Figure 27 & Figure 28**.

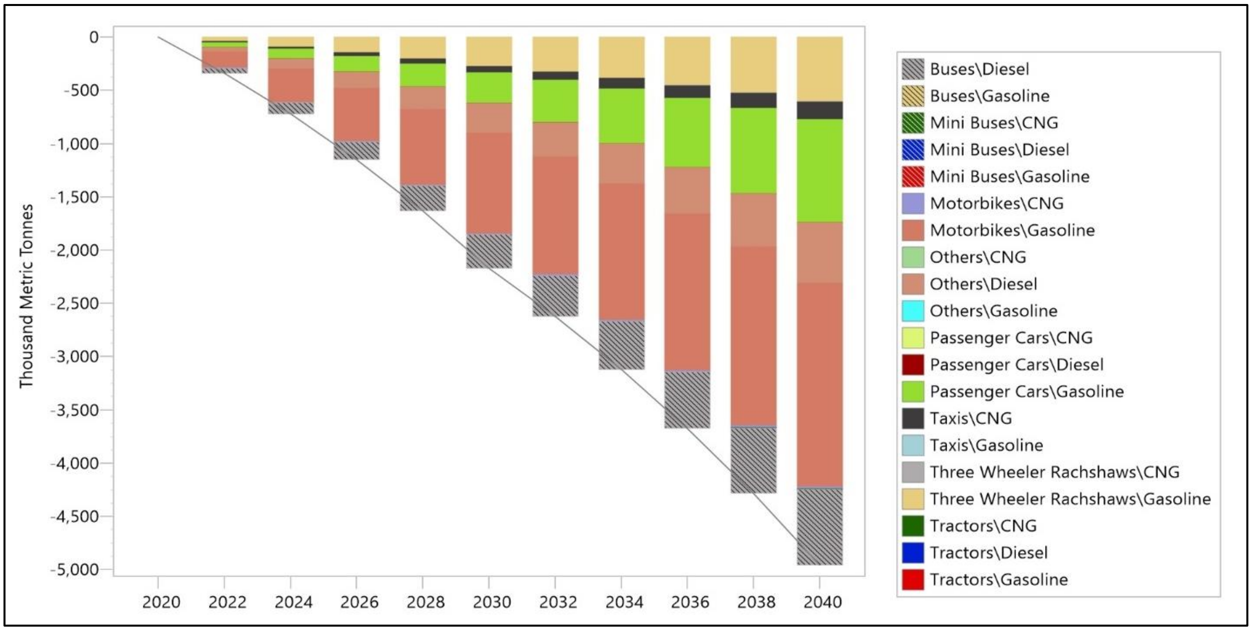


Figure 27 Emission Reductions in Passenger Road Transport due to the Penetration of EVs.

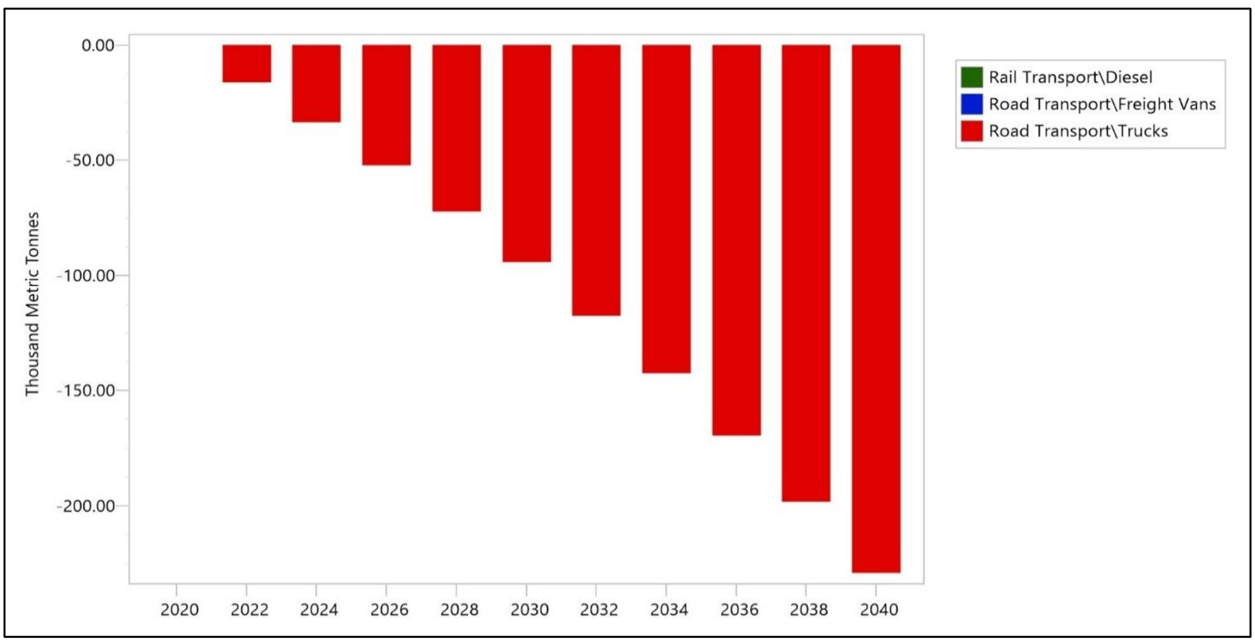


Figure 28 Emission Reductions in Freight Road Transport due to Penetration of EVs

4.3. Model Validation and Limitations

The LEAP model used in this research has been validated through different studies for both base-year optimization as well as future projections. This has been done to ensure that the model formulation as well as structuring caters for the need of

Pakistan's transport sector. The model check done through various studies is further described in detail in **Table 9.**

Table 9 LEAP Model Validation

Sr. No	Validation Approach	Model Values	Benchmarked Source Value	% Error
1	Base Energy Total Energy Demand	14. 9 Mtoe	Pakistan Energy Yearbook (2020) = 15.6 Mtoe	4.4 %
2	Base Year Emissions	58 Mt	Pakistan Climate Transparency Report = 55 Mt	5.45 %
3	Cumulative Emission reductions through EVs	24 Mt	NDC values = 22 Mt	9.09 %
4	Base Year Running Cost	$16.1 billion	Study on Green Recovery in Energy and Power Sector of Pakistan = $18 billion	10.5%

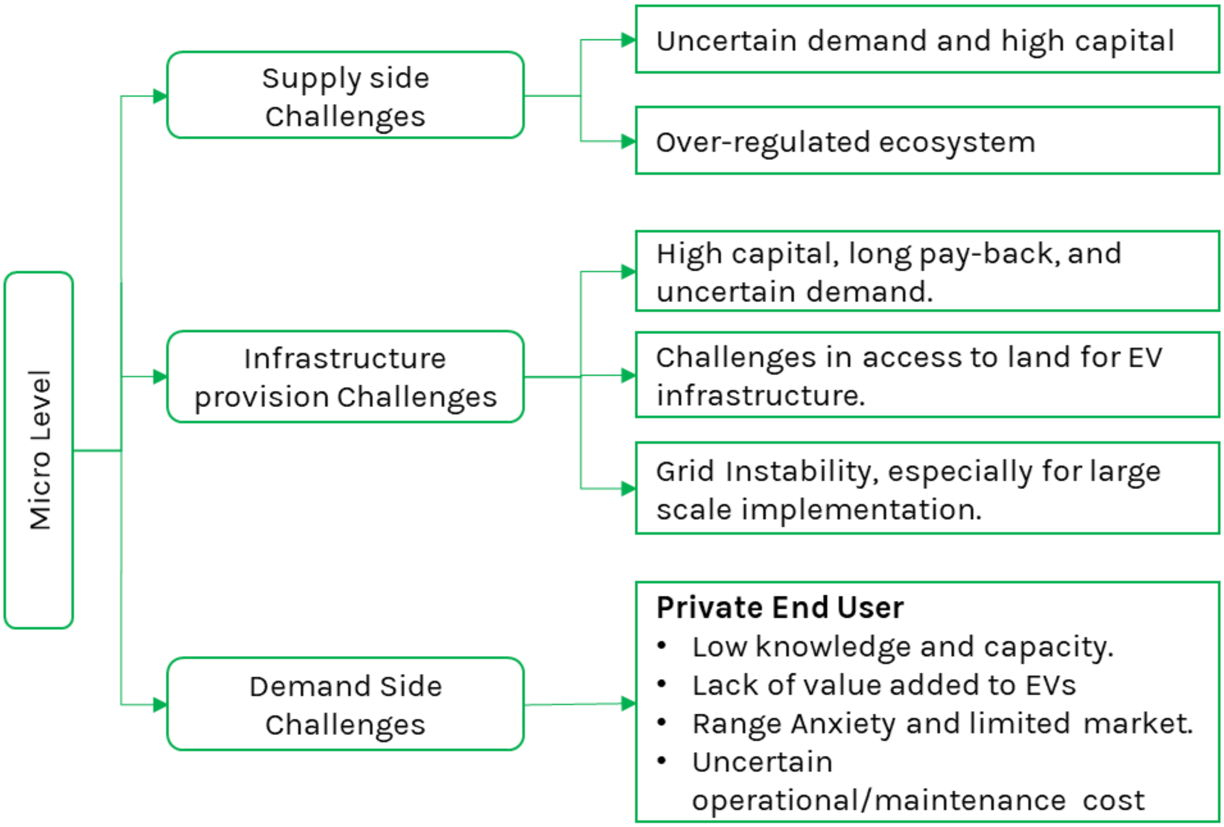
While the model has been optimized using the latest data and interventions available, the results are valid and acceptable under the set of assumptions and limitations as mentioned below:

- The energy demand, running cost, and emissions associated with national and international shipping are not considered.
- The emission factors and environmental loading is done using IPCC 6th assessment report.
- The average annual vehicle travel values for freight and rail transport are projected for 2020 using the latest available values of 2017.
- The passenger load factor for some vehicle categories is taken from the average values of Asian countries.
- The emissions resulting from the generation of electricity for fulfilling EV requirements are not incorporated in the model.
- Since the EV policy does not include hybrid vehicles, they are not penetrated in the model as EVs.
- Fuel price fluctuations for gasoline, diesel, CNG, and electricity are not incorporated in the model. The fuel costs are assumed to remain the same over the modeling horizon.

5. CHAPTER 5: POLICY RECOMMENDATIONS AND THE WAY FORWARD

The transport sector has been among the largest consumer of petroleum products in Pakistan. Since most of these products are imported, it majorly contributes to the import bill and consequently increases the trade deficit. Unlike other sectors (power & residential), which have shown some improvements over the past few years, energy transition measures of the transport sector have been minimal. The vehicle stock as well as fuel quality has not been able to transition from Euro-II to Euro-V, Larger travel demand is from private transport, constantly reducing the use of railways for both passenger and freight, and almost negligible stock of EVs. Given the deteriorating fiscal space of the country, managing the transport sector is soon expected to be a major burden on the economy.

To counter these challenges, this study has identified the use of EVs to be a key alternative. However, given the current infrastructure and lack of consistency in policies and regulatory frameworks, there is a need to bring significant reform measures. A summary of both macro and micro-level challenges for large-scale adoption of EVs in Pakistan are depicted in the figure below .



Driven by the above-mentioned challenges, this section particularly highlights the way forward against the backdrop of EVs. These recommendations are derived from the extensive desk review, analysis on industrial EV preparedness, and the LEAP model developed to analyze the impacts of electric vehicles penetration.

Despite an increase in the number of EV models in Pakistan in 2022, the challenge for bringing the country in compliance with the EV policy targets is enormous. Specific policy support and model expansion would be extremely critical for mitigating emissions and making a progress towards the NDCs.

Given the high capital cost of EVs, the short-term solution must focus on making EVs cost competitive through differential taxation of vehicles and reinforcing the regulatory measures that will enable the clean energy vehicle industry to thrive. For a comparatively longer run integration of EVs into the power system, decarbonizing the electricity generation, deployment of recharging infrastructure, and indigenization of technology would be the key to success.

Recommendation 1: Bringing Consistency in Targets of EV Policy and Regulatory Frameworks

1. The government must identify the dedicated department, institution, and ministry that takes the ownership of Pakistan's EV policy. That dedicated department must also finalize the implementation plan for the EVs, ranging from their manufacturing to disposal.
2. EV targets and incentives offered under the policies of MoCC and MoIP must be brought in line with the investors' interest.
3. Bodies at the federal (PSQC) and provincial (PTA) levels must act in coordination to remove the existing differences in standards provided for the EV parts.

Recommendation 2: Obtaining the Critical Mass Number of EVs by Initially Converting Government Vehicles into Electric.

For early adoption of EVs, demand creation is critical. For a rapid uptake of electric vehicles and their infrastructure, there is a need to attain the initial critical mass number that builds the interest of both public and private investors. The government can uptake this initiative by initially converting the government-owned vehicles into an electric fleet. Moreover, public awareness through digital media, print media, and comprehensive portals can be used to educate the public and remove negative preconceptions about electric vehicles.

Recommendation 3: Rapid Increase in the Development of Critical EV Infrastructure Across Motorways and Highways through Public Private Partnership.

Given that currently the major challenge for EVs is long distance travel, motorways and highways are the most critical links where EV charging stations must be installed on priority. This would ensure the long distance connectivity while also providing a faster Rate of Return (RoR) to the installation companies.

For an effective private sector participation in building this infrastructure, financial instruments such as credit systems, preferential loan offers, tax reduction schemes, and lower import duty for EV infrastructure can be provided.

Recommendation 4: Localization of EV Technology, Including Manufacturing and Assembly of EV Components, Battery Cells, and Software Packages Used Within the EV.

To bring the cost of EV at par with ICE vehicles and reduce Pakistan's trade deficit, it is essentially critical to localize all components of the EV value chain. This would further create local business opportunities and green jobs.

Recommendation 5: Provision of Subsidies and Incentives for Electric Vehicles and Supporting Infrastructure

To ensure rapid growth at the initial stage, there is a need to ensure the provision of subsidies and incentives for the EV supply chain. This includes:

- Free Registration for EVs
- Relaxation in Customs Duties and Import Levies
- Duty and Tax Incentives for Local Manufacturing
- Reduced Tolls on Motorways and Other Highways
- Reduced Taxation on EV-related Appliances
- Reduced Power Tariffs for the Charging of EVs (both at homes and EV charging stations)
- Mandatory Installation of EV Infrastructure for All New Real Estate Projects
- Provision of Early Bird Incentives (which may include the premium offered to a particular number of first customers)
- Provision of Scrappage Incentive to Individuals/Companies that are Converting ICEs into EVs.
- Provision of EV Installation Tenders on Behalf of the GoP to Showcase the Interest of the Public Sector
- Provision of EV Bonds and Government-backed Loans for Installing EV Infrastructure

Recommendation 6: Ensuring the Quality of Imported or Locally Manufactured Electric Vehicle Through the Provision of UIN to Batteries and Other EV Components

Given that safety is a major concern for the EV industry, the dedicated departments at the provincial and federal level of Pakistan must take necessary steps to ensure EV safety, particularly of its battery setup. This may include:

- Giving a UIN (unique identification number) at the manufacturing or import stage to EV batteries through which the EV supplier or OEM can be tracked in case of any accident.

Recommendation 7: Ensuring Inter Operate ability of EV components and IT infrastructure

To overcome standardization issues with the EV supply chain, the developers and OEMs must develop an inter operate ability framework which can include the following:

- Standardization of battery packs for EVs, and implementation of uniform charging standards
- Developing a standard protocol between battery management systems for software reinstallations/reboots
- Developing local testing facilities that can certify EVs, batteries, and EVSEs that are either imported or locally-manufactured.
- A strict oversight must be maintained on EVs that are converted from ICEs.

Recommendation 8: Introducing a Single Window Clearance for the Registration of Electric Vehicles

For providing the ease of business in registering electric vehicles and initiating an EV-linked startup, there is need to develop an enabling framework. This may include:

- Introducing a single-window online portal system of all consulting stakeholders to fast-track the registration process (This would further ease the documentation period and identify the stakeholders, who are causing process delays.)
- Enabling the private sector through joint ventures with international companies for the local manufacturing of EVs and its supporting infrastructure

Recommendation 9: Capacity Building and Outreach Programs for the EV Market.

For off-take of EVs, the socio-economic advantages of EV ownership must be advocated to the local communities. This would require:

- Dedicated outreach and capacity-building programme driven by the government in support from the public sector and CSOs
- Capacity building of the ICE workforce must also be carried out with a targeted skill developments to work in the EV industry

Recommendation 10: Incentivizing the rooftop solar for charging stations

Ministry of Energy in collaboration with National Electric Power Regulatory Authority (NEPRA) i can formulate an incentive for using rooftop solar by giving a preferential net metering scheme for electric mobility infrastructure. This may also be coupled with the provision of a Smart EV Tariff Structure by NEPRA.

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ANNEXURES

Annexure 1: Production and Sales of Vehicles in Pakistan (2021)

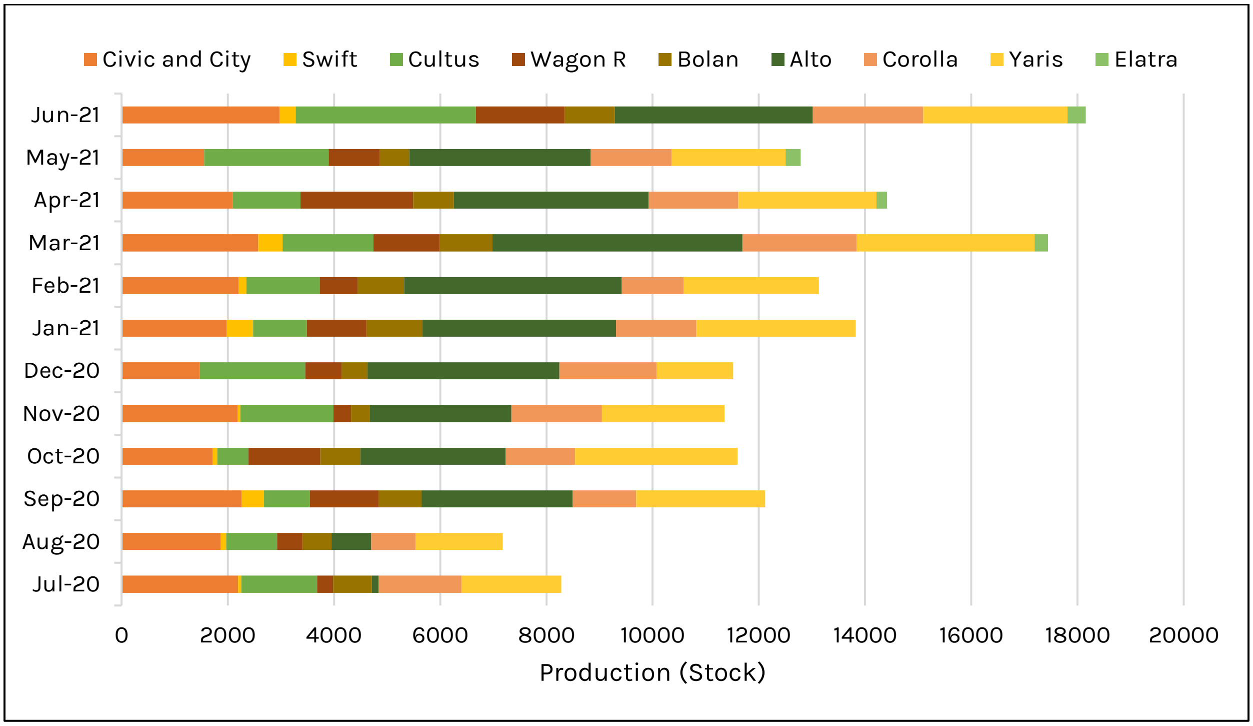

Figure 29 Production of Passenger Cars in 2021

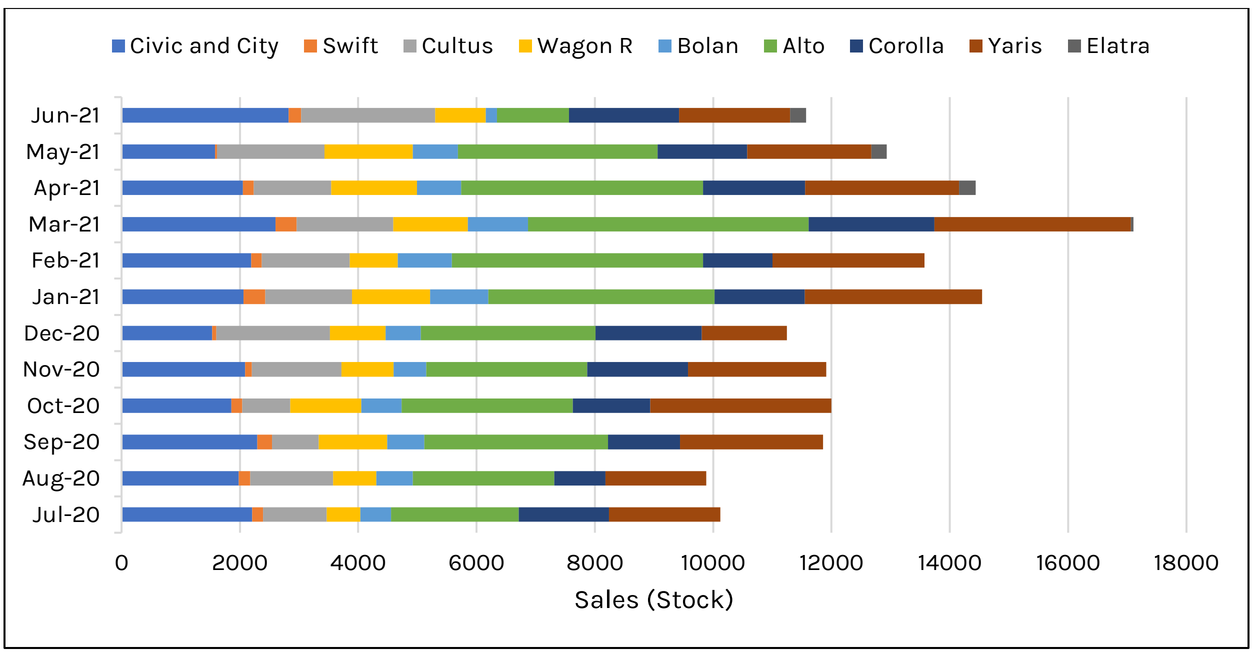

Figure 30 Sales of Passenger Cars in 2021

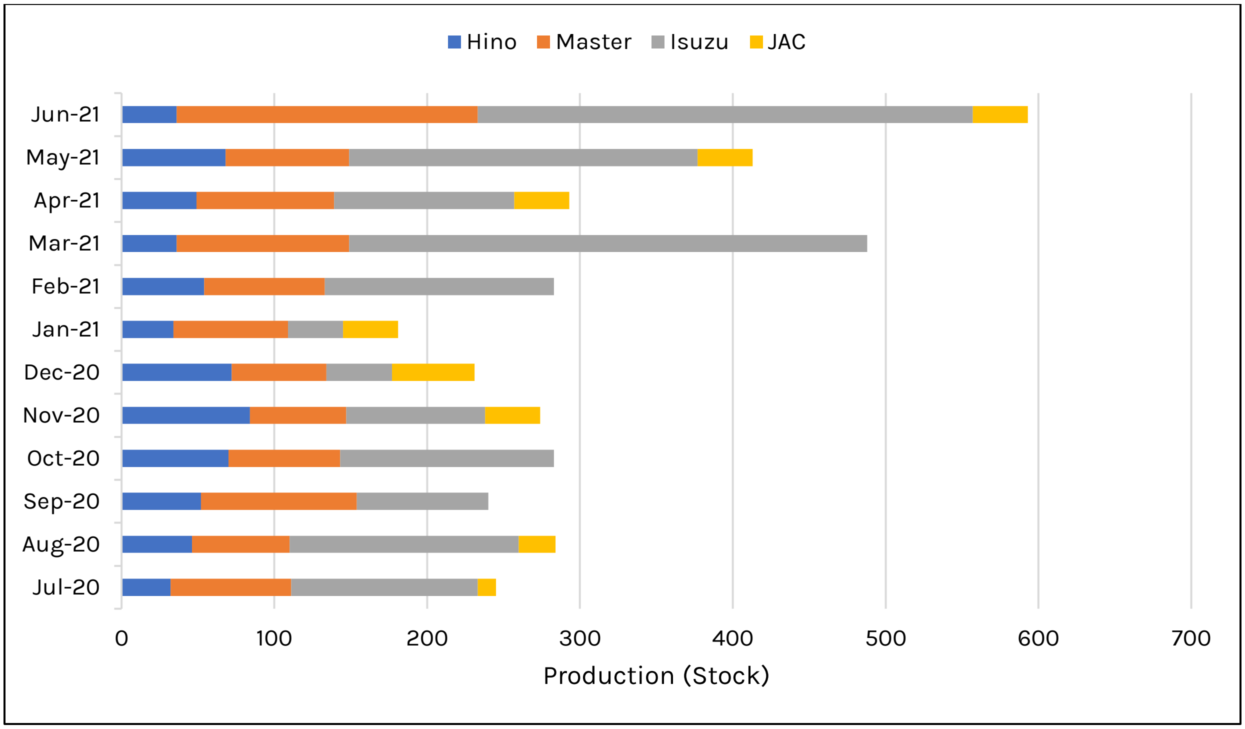

Figure 31 Production of Trucks in 2021

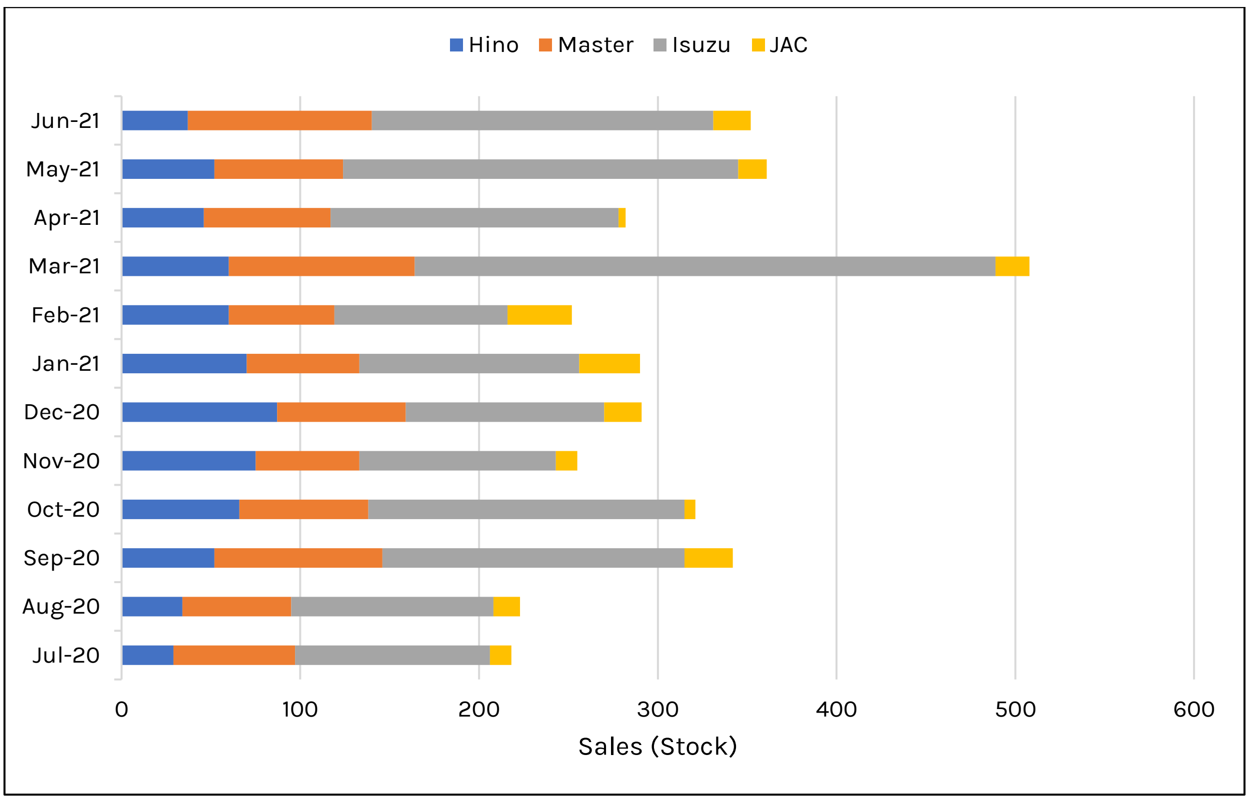

Figure 32 Sales of Trucks in 2021

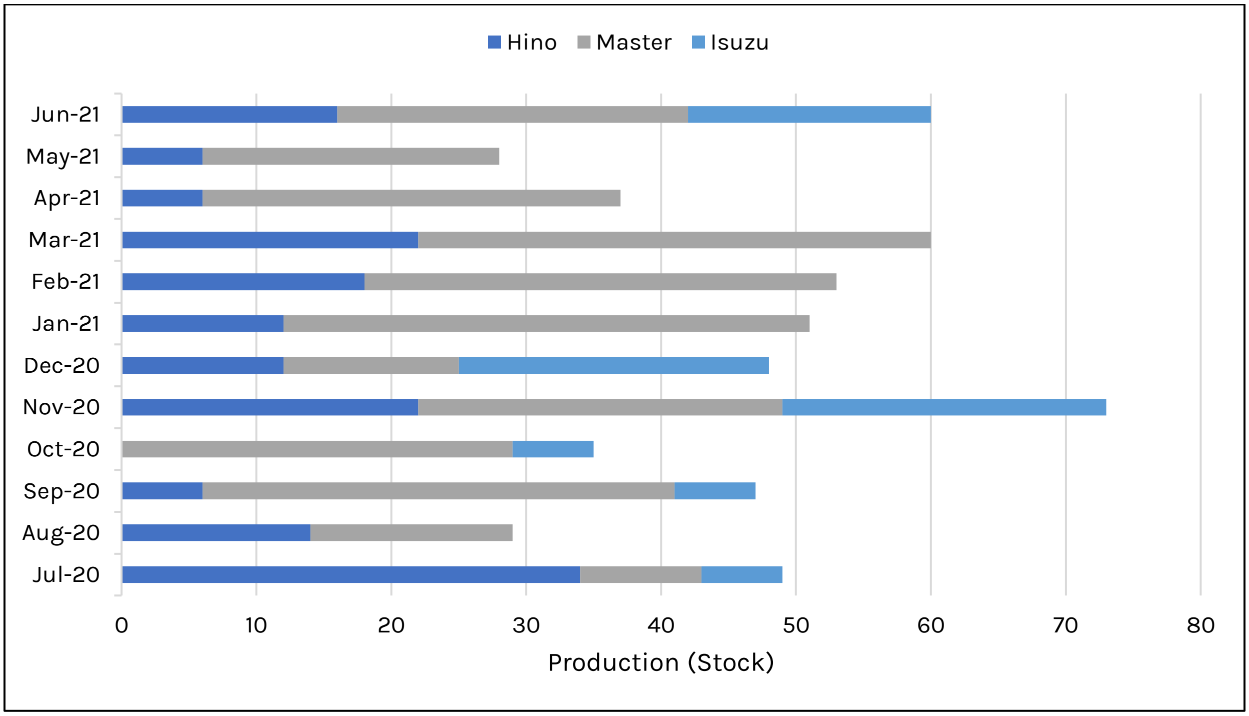

Figure 33 Production of Buses in 2021

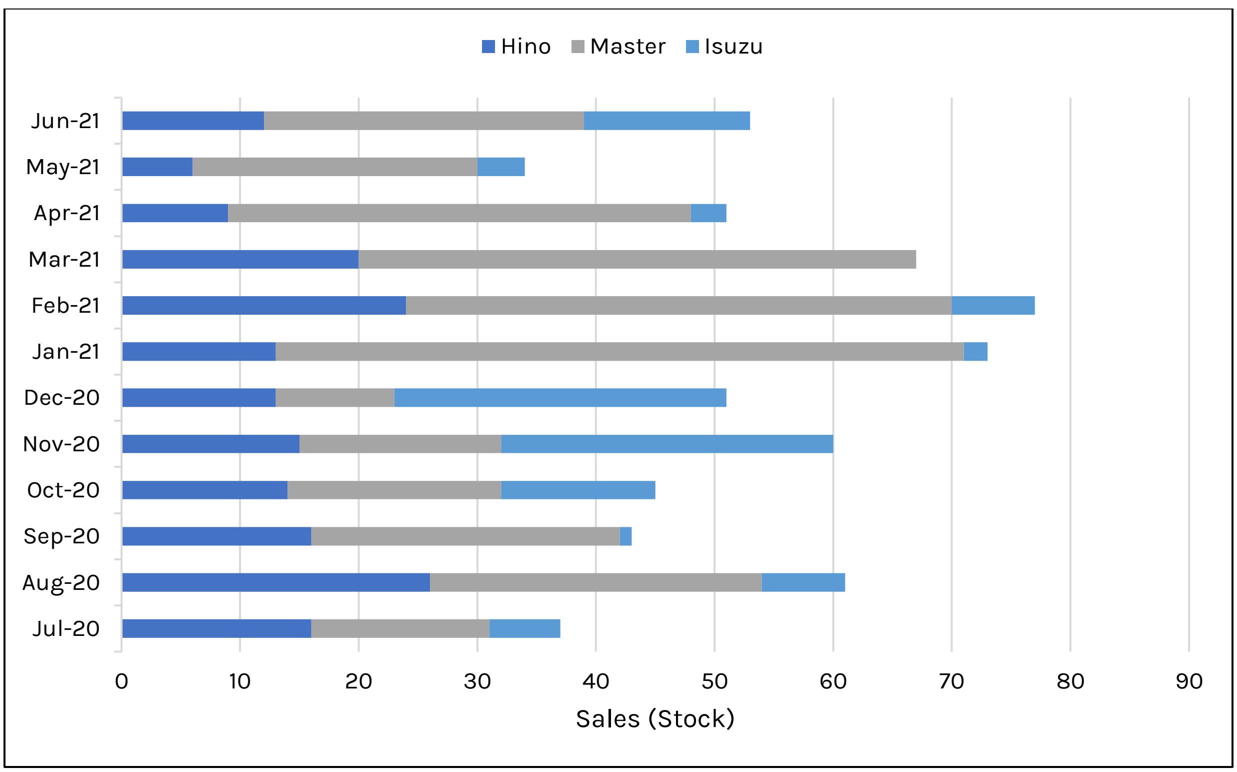

Figure 34 Sales of Buses in 2021

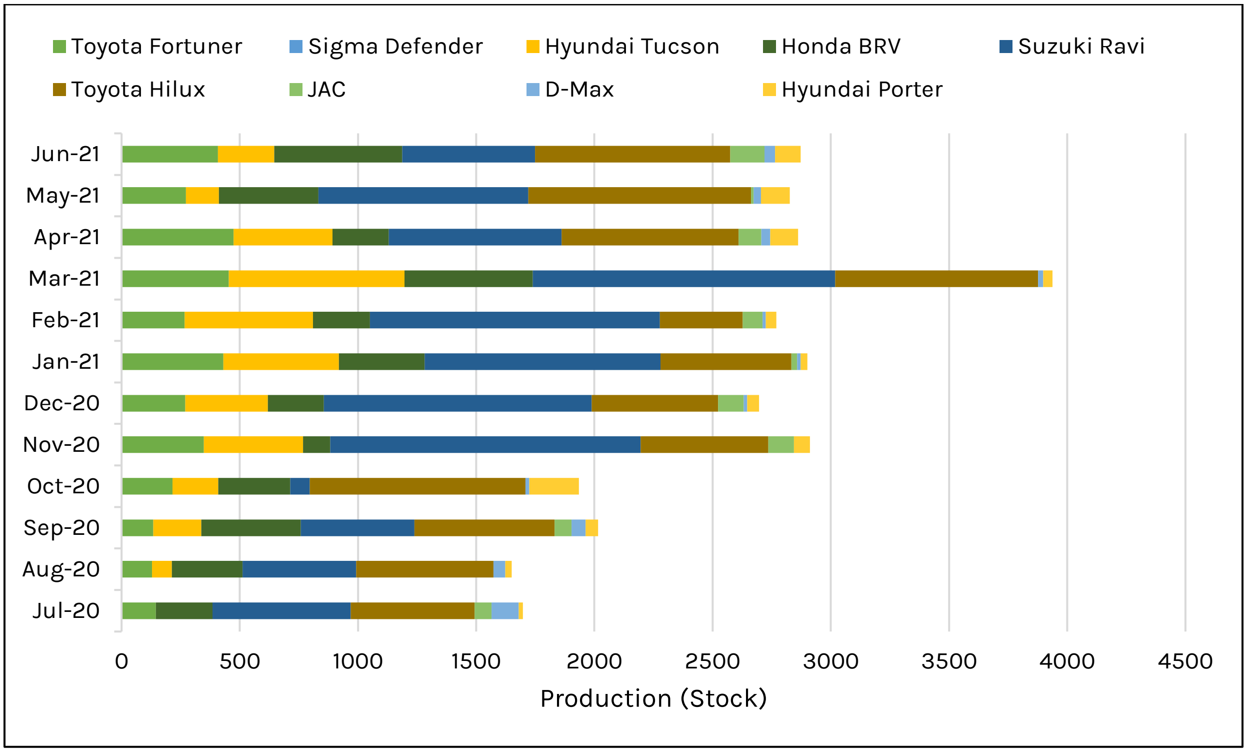

Figure 35 Production of LCVs, Vans, and Jeeps in 2021

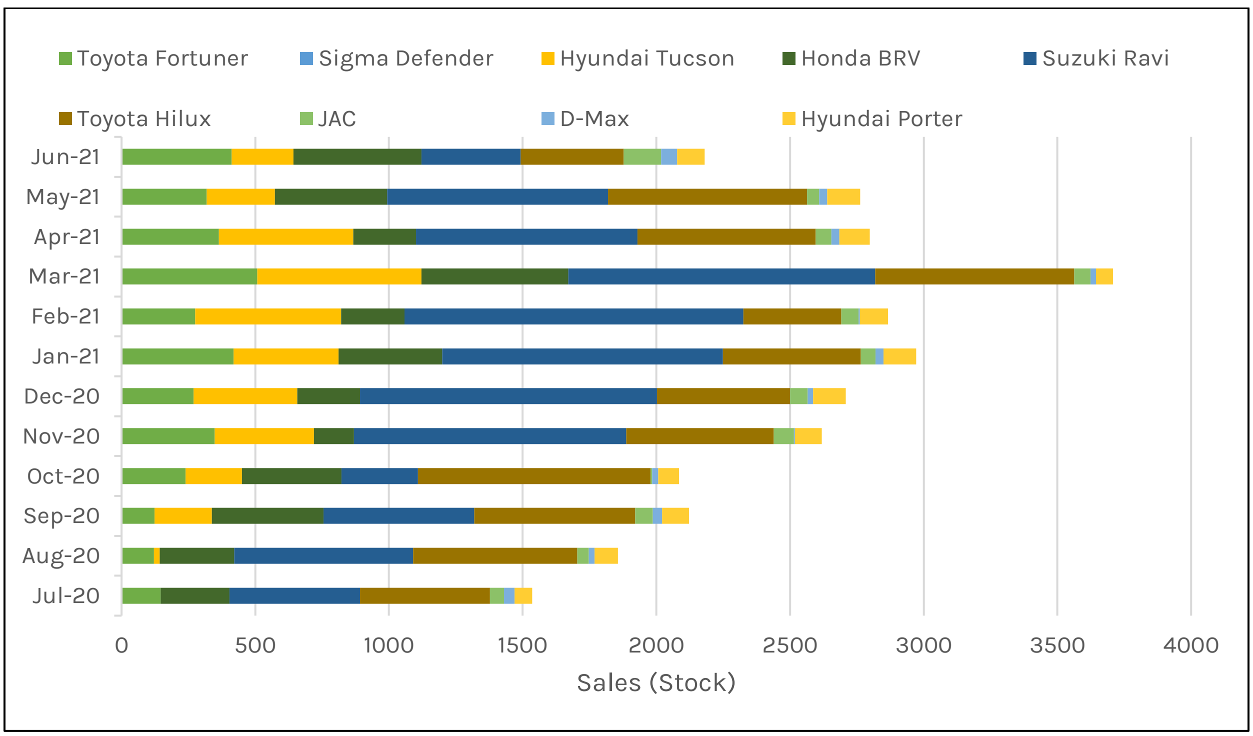

Figure 36 Sales of LCVs, Vans, and Jeeps in 2021

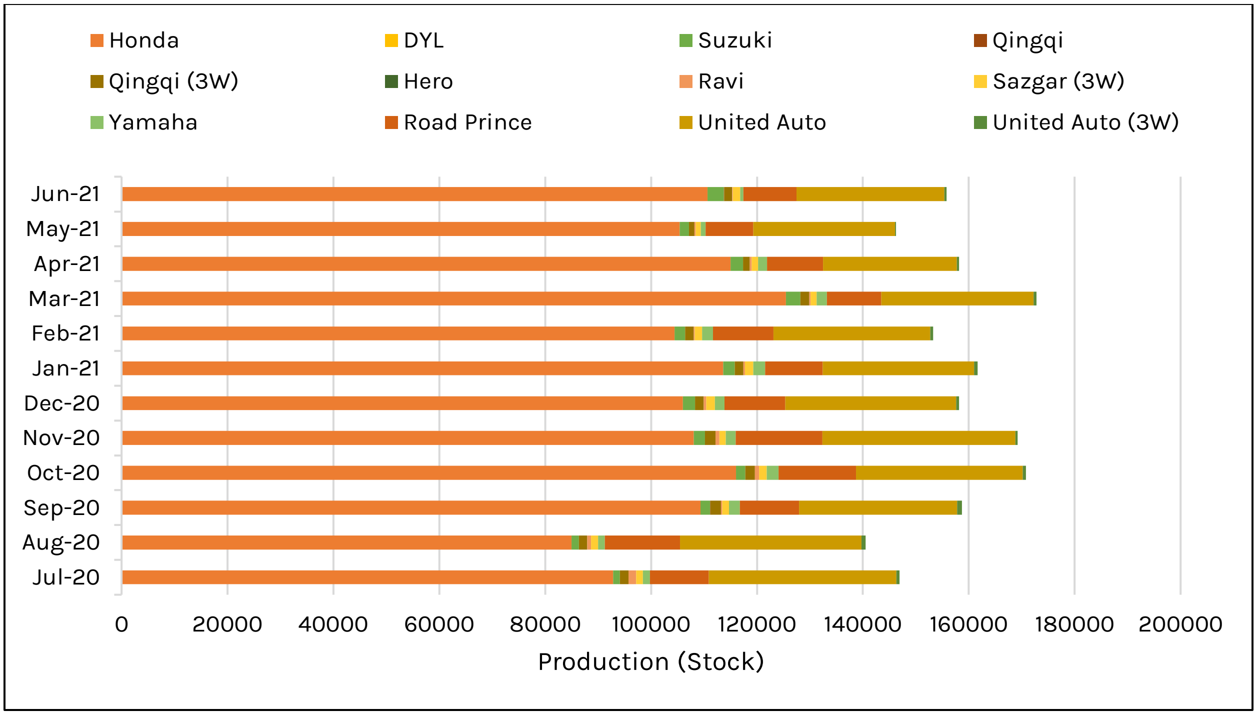

Figure 37 Production of 2-Wheelers and 3-Wheelers in 2021

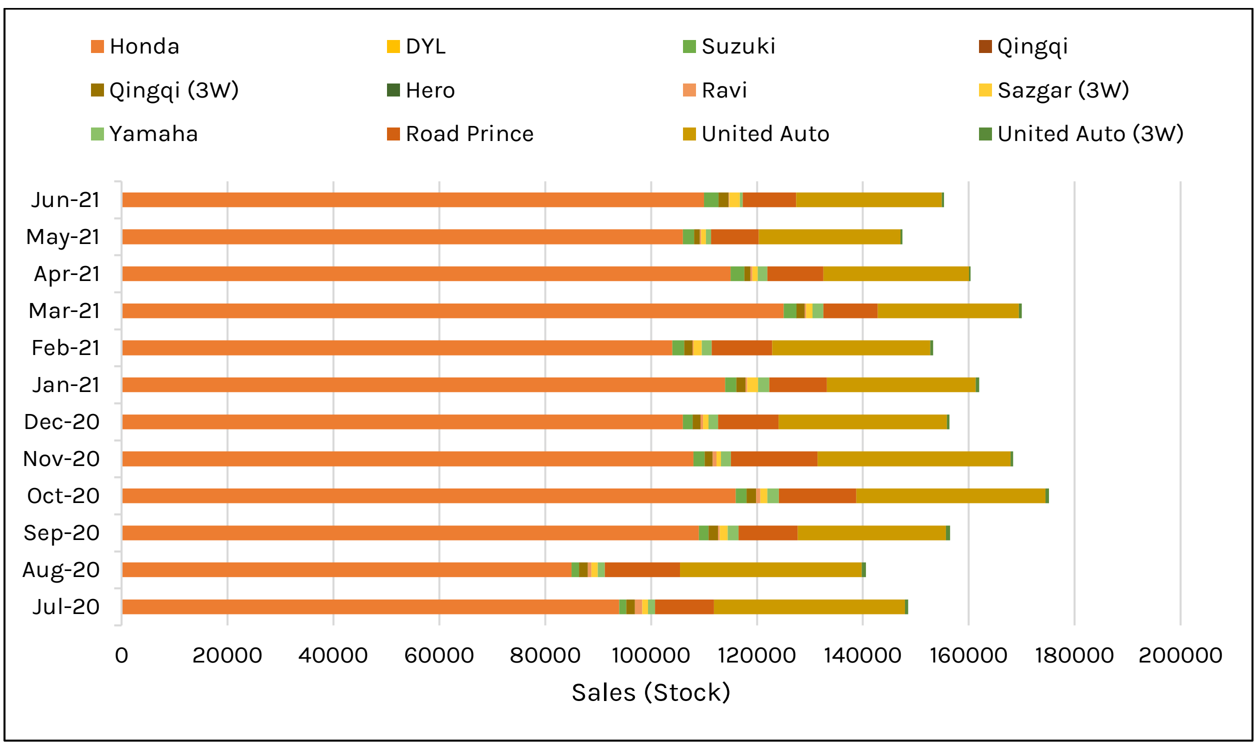

Figure 38 Sales of 2-Wheelers and 3-Wheelers in 2021

Annexure 2: Interface and Structure of the LEAP Model

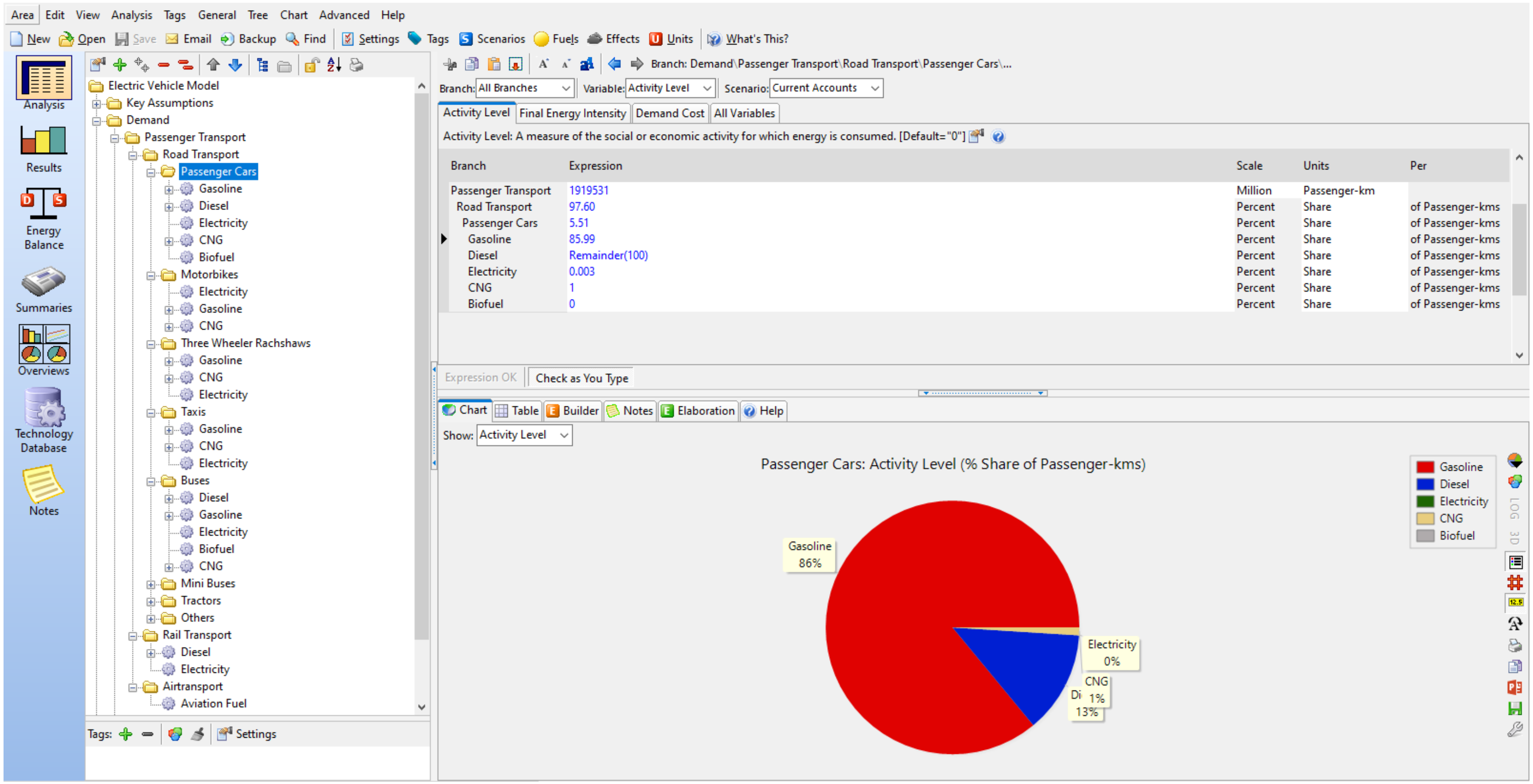

Figure 39 LEAP Modeling Tree

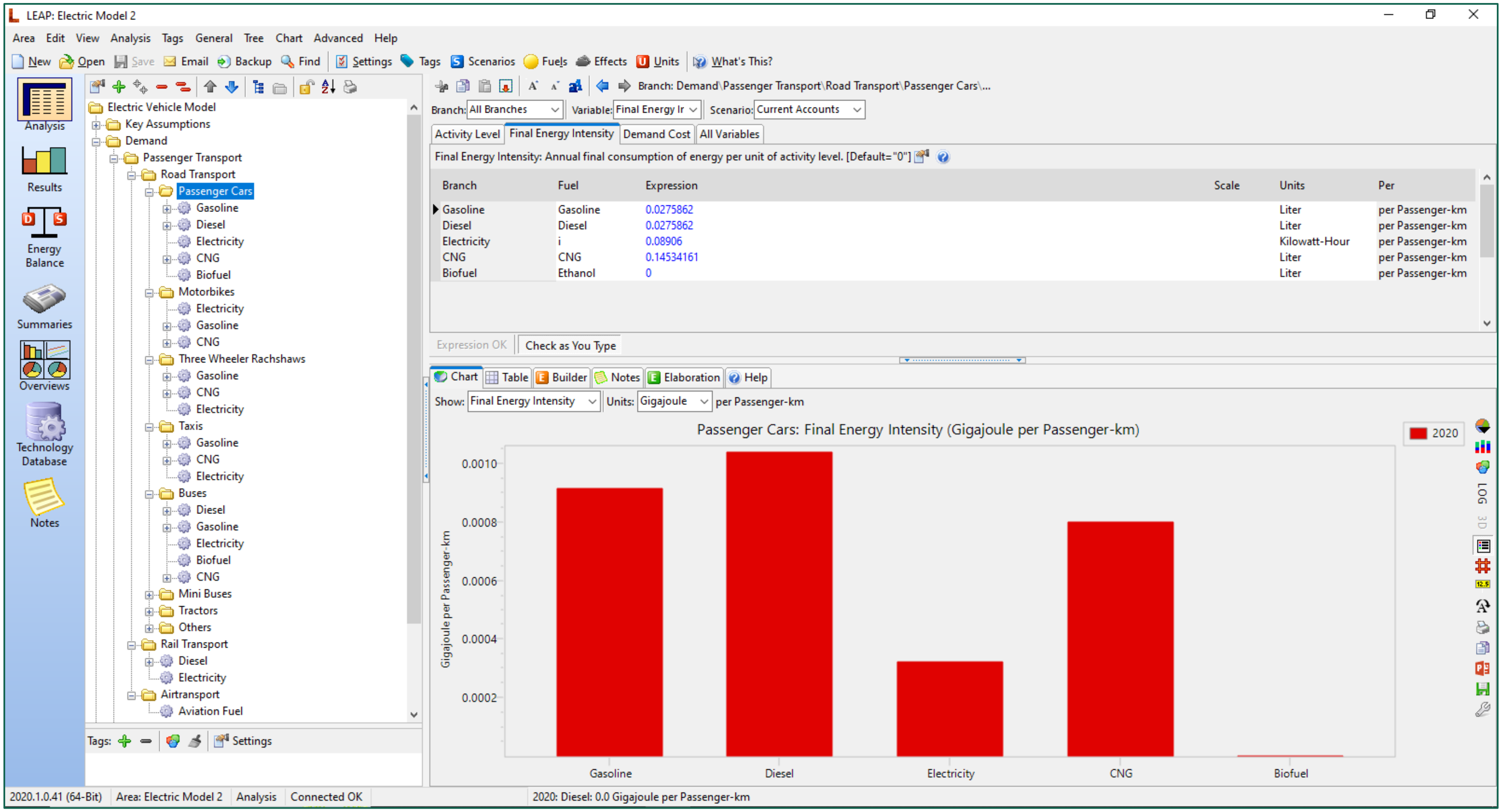

Figure 40 Energy Intensity and Demand Cost entries

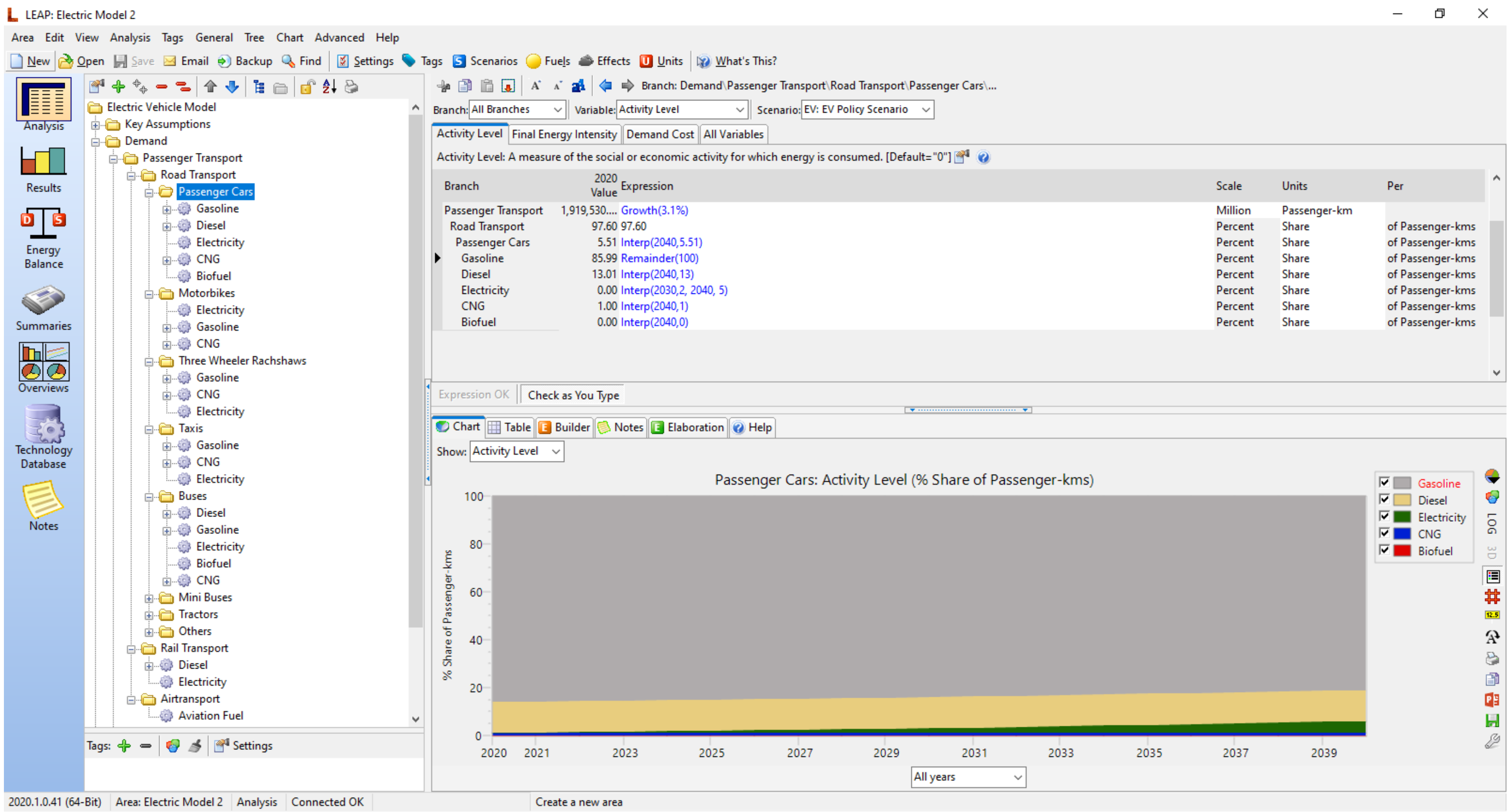

Figure 41 Date entries for Scenario Modeling

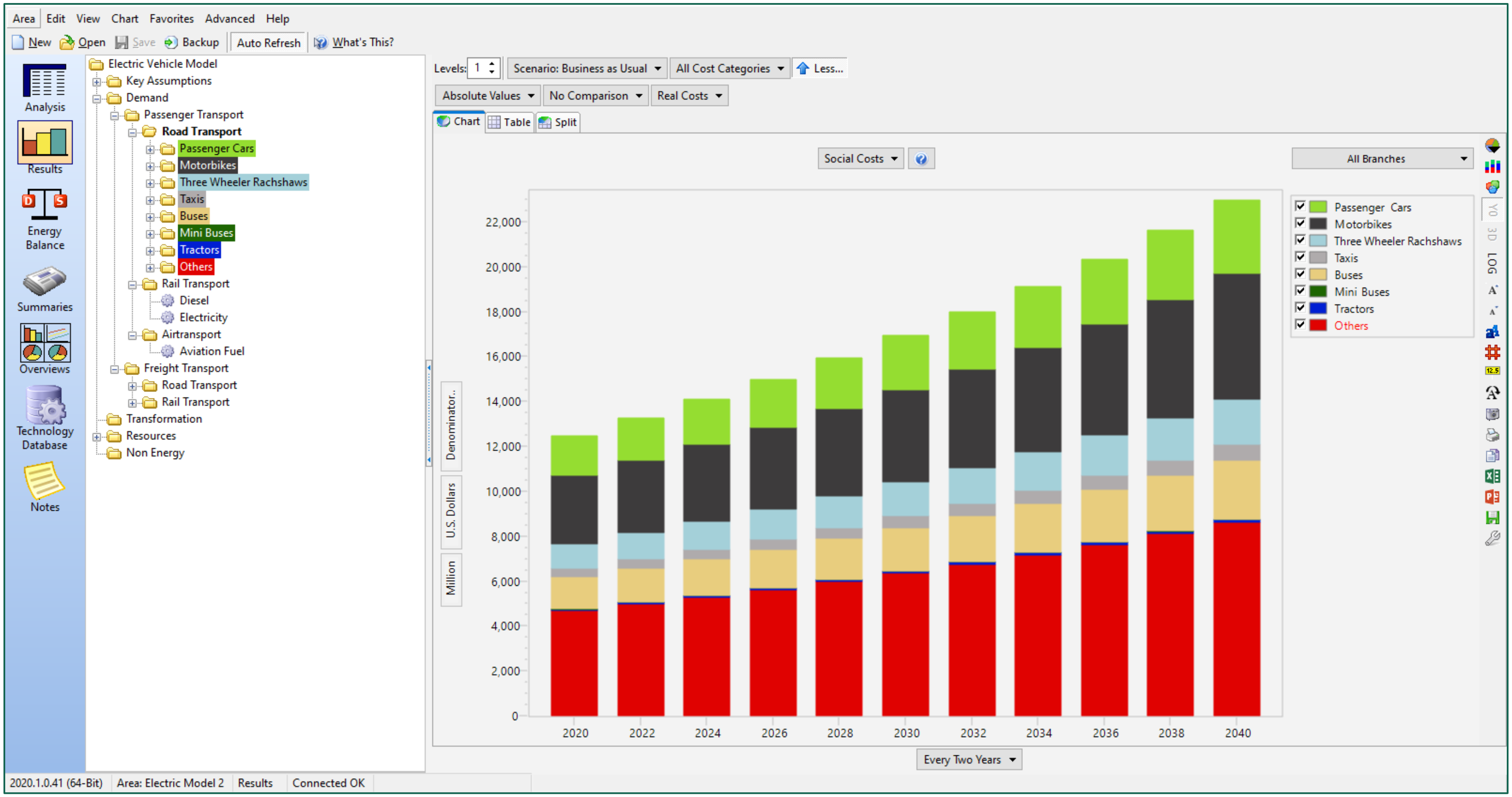

Figure 42 Analyzing the modeling results

Annexure 3: Base Year Data Set

Passenger Transport	Fuel	Registered Vehicles (veh)	annual travel distance pe (km)	Vehicle Use (Million veh-km)	Load Factor (pass-km/veh-km)	Passenger km (Million pass-km)	Fuel	Unit	Energy Intensity (liters/pass-km)	Energy Consumption kTOE
Passenger Car		3,772,835				103,281				2292.84
Car Gasoline	Gasoline	3,244,263	10,950	35,525	2.5	88,812	14.50	km/l	0.0275862	1939.95
Car Diesel	Diesel	490,469	10,950	5,371	2.5	13,427	14.50	km/l	0.0275862	333.49
Car AFV	Biofuel	-	10,950	0	2.5	0	14.50	km/l	0.0275862	0.00
Car Electric	Electricity	103	10,950	1	2.5	3	40.00	km/l	0.0100000	0.02
Car Gas	Natural Gas	38,000	10,950	416	2.5	1,040	17.00	km/l	0.0235294	19.38
Motorbike		22,707,368				201,314				3113.37
Bike Gasoline	Gasoline	22,707,126	5,541	125,820	1.6	201,312	32.00	km/l	0.0195313	3113.35
Bike Diesel	Diesel	-	5,541	0	1.6	0	32.00	km/l	0.0195313	0.00
Bike AFV	Biofuel	-	5,541	0	1.6	0	32.00	km/l	0.0195313	0.00
Bike Electric	Electricity	242	5,541	1	1.6	2	50.00	km/l	0.0125000	0.02
Bike Gas	Natural Gas	-	5,541	0	1.6	0	32.00	km/l	0.0195313	0.00
Taxi		171,231				24,375				498.54
Taxi Diesel	Diesel	-	54,750	0	2.6	0	12.00	km/l	0.0320513	0.00
Taxi Gasoline	Gasoline	113,231	54,750	6,199	2.6	16,118	14.00	km/l	0.0274725	350.63
Taxi Gas	Natural Gas	58,000	54,750	3,176	2.6	8,256	17.00	km/l	0.0226244	147.91
Auto Rickshaw		939,384				56,363				1373.22
Rickshaw Gasoline	Gasoline	932,264	24,000	22,374	2.5	55,936	13.00	km/l	0.0307692	1362.81
Rickshaw CNG	Natural Gas	7,120	24,000	171	2.5	427	13.00	km/l	0.0307692	10.41
Bus		254,778				1,192,361				1989.95
Bus Gasoline	Gasoline	0	72,000	0	65	0	8.50	km/l	0.0018100	0.00
Bus Diesel	Diesel	254,778	72,000	18,344	65	1,192,361	8.30	km/l	0.0018536	1989.95
Bus AFV	Biofuel	0	72,000	0	65	0	3.00	km/l	0.0051282	0.00
Bus Electric	Electricity	0	72,000	0	65	0	10.00	km/l	0.0015385	0.00
Bus Gas	Natural Gas	0	72,000	0	65	0	8.30	km/l	0.0018536	0.00
Tractor		634,000				1,141				95.14
Tractor Gasoline	Gasoline	0	1,000	0	1.8	0	6.00	km/l	0.0925926	0.00
Tractor Diesel	Diesel	634,000	1,000	634	1.8	1,141	6.00	km/l	0.0925926	95.14
Tractor AFV	Biofuel	0	1,000	0	1.8	0	6.00	km/l	0.0925926	0.00
Tractor Electric	Electricity		1,000	0	1.8	0	6.00	km/l	0.0925926	0.00
Tractor Gas	Natural Gas	9	1,000	0	1.8	0	6.00	km/l	0.0925926	0.00
Mini Bus		75				54				0.45
Mini Bus Gasoline	Gasoline	0	60,000	0	12	0	8.50	km/l	0.0098039	0.00
Mini Bus Diesel	Diesel	0	60,000	0	12	0	8.29	km/l	0.0100523	0.00
Mini Bus AFV	Biofuel	0	60,000	0	12	0	8.00	km/l	0.0104167	0.00
Mini Bus Electric	Electricity	0	60,000	0	12	0	8.00	km/l	0.0104167	0.00
Mini Bus Gas	Natural Gas	75	60,000	5	12	54	8.00	km/l	0.0104167	0.45
Others		1,823,975				262,652				1359.31
Other Gasoline	Gasoline	1,823,975	8,000	14,592	18	262,652	8.50	km/l	0.0065359	1359.31
Other Diesel	Diesel	0	8,000	0	18	0	10.00	km/l	0.0055556	0.00
Other CNG	Natural Gas	0	8,000	0	18	0	8.30	km/l	0.0066934	0.00
Freight Transport	**Fuel**	**Registered Vehicles (veh)**	**annual travel distance pe (km)**	**Vehicle Use (Million veh-km)**	**Load Factor (tonne-km/veh-km)**	**Freight km (Million tonne-km)**	**Fuel**	**Unit**	**Energy Intensity (liters/tonne-km)**	**Energy Consumption kTOE**
Truck		295,023				142,142				1401.77
Truck Gasoline	Gasoline	0	43,800	0	11	0	8.30	km/l	0.0109529	0.00
Truck Diesel	Diesel	295,023	43,800	12,922	11	142,142	8.30	km/l	0.0109529	1401.77
Truck AFV	Biofuel	0	43,800	0	11	0	8.30	km/l	0.0109529	0.00
Truck Electric	Electricity	0	43,800	0	11	0	8.30	km/l	0.0109529	0.00
Truck Gas	Natural Gas	0	43,800	0	11	0	8.30	km/l	0.0109529	0.00
Freight Van		309,000				81,576				510.07
Van Gasoline	Gasoline	0	22,000	0	12	0	12.00	km/l	0.0069444	0.00
Van Diesel	Diesel	309,000	22,000	6,798	12	81,576	12.00	km/l	0.0069444	510.07
Van AFV	Biofuel	0	22,000	0	12	0	12.00	km/l	0.0069444	0.00
Van Electric	Electricity	0	22,000	0	12	0	12.00	km/l	0.0069444	0.00
Van Gas	Natural Gas	0	22,000	0	12	0	12.00	km/l	0.0069444	0.00

Annexure 4: Energy Demand of Different Subsectors Under the BAU Scenario.

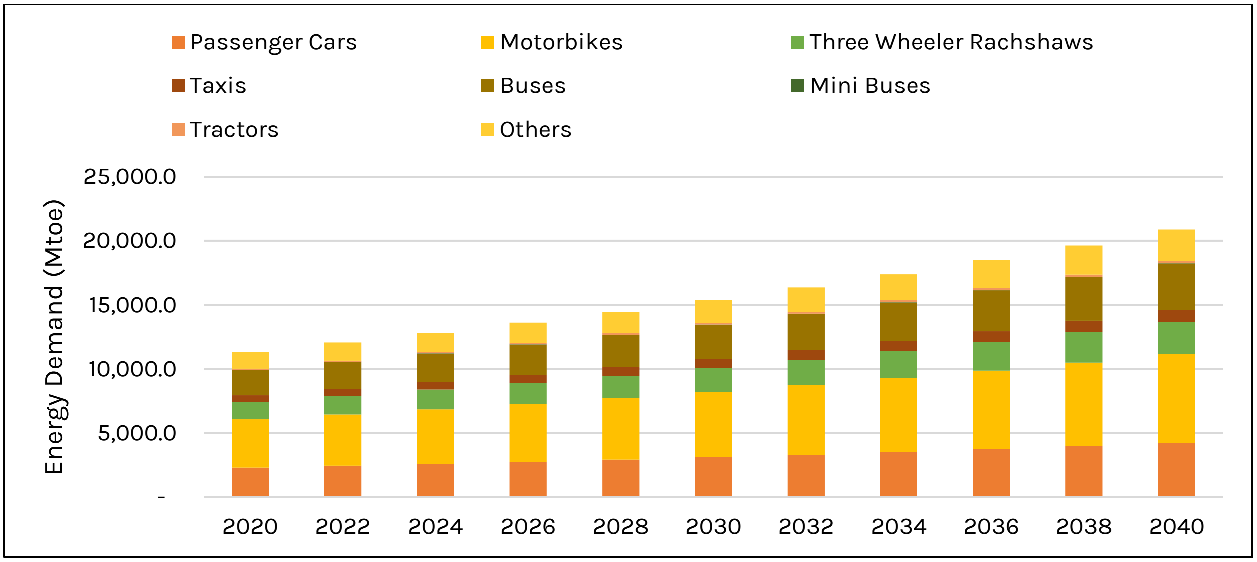

Figure 43 Energy Demand of Passenger Road Transport under BAU Scenario

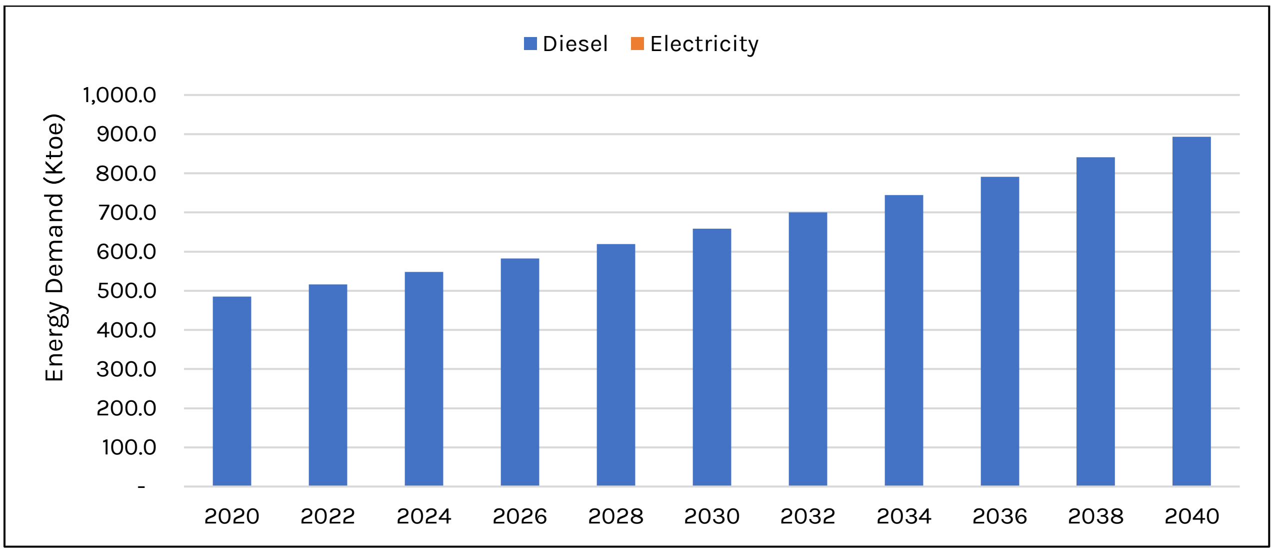

Figure 44 Energy Demand of Passenger Rail Transport

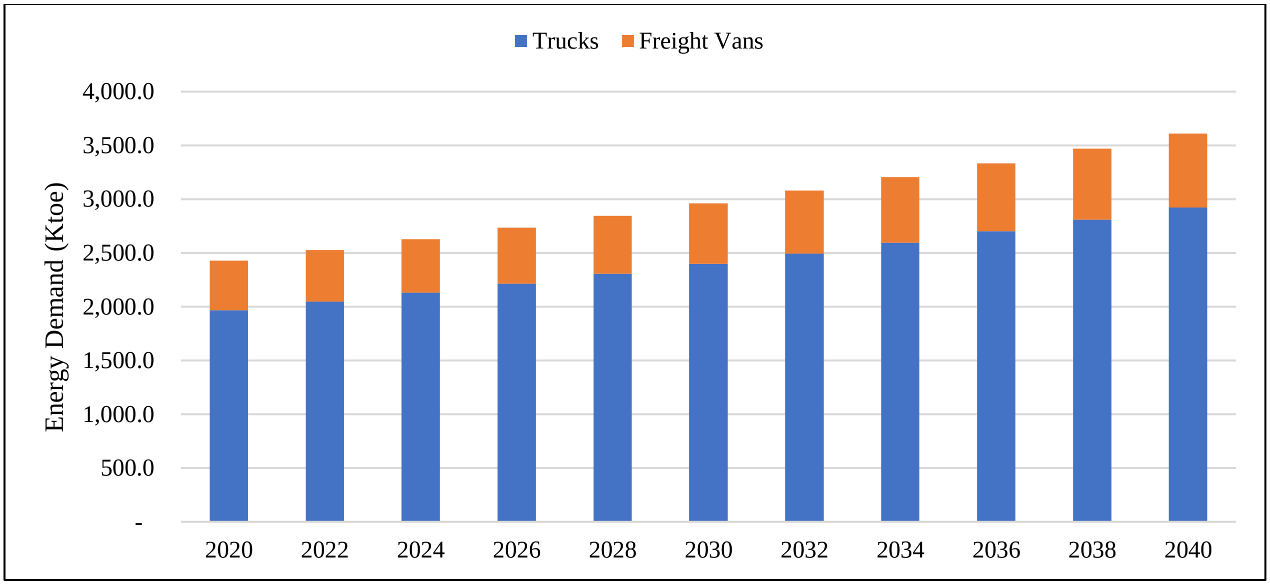

Figure 45 Energy Demand of Freight Road Transport Under the BAU Scenario

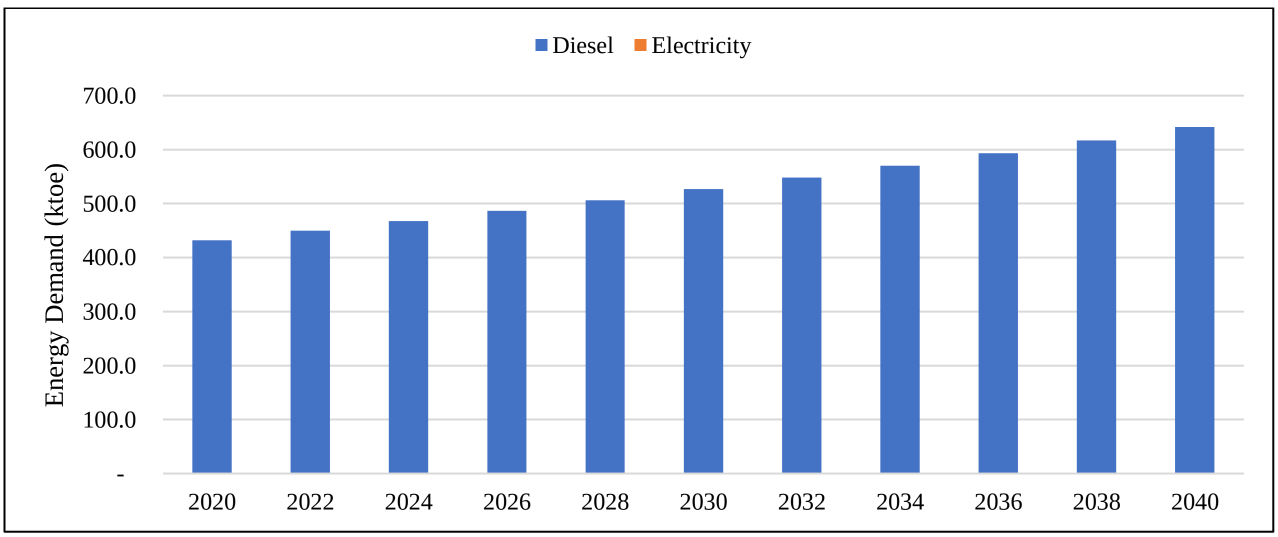

Figure 46 Energy Demand of Freight Rail Transport Under the BAU Scenario

Annexure 5: Electricity Consumption in Different Transport Categories

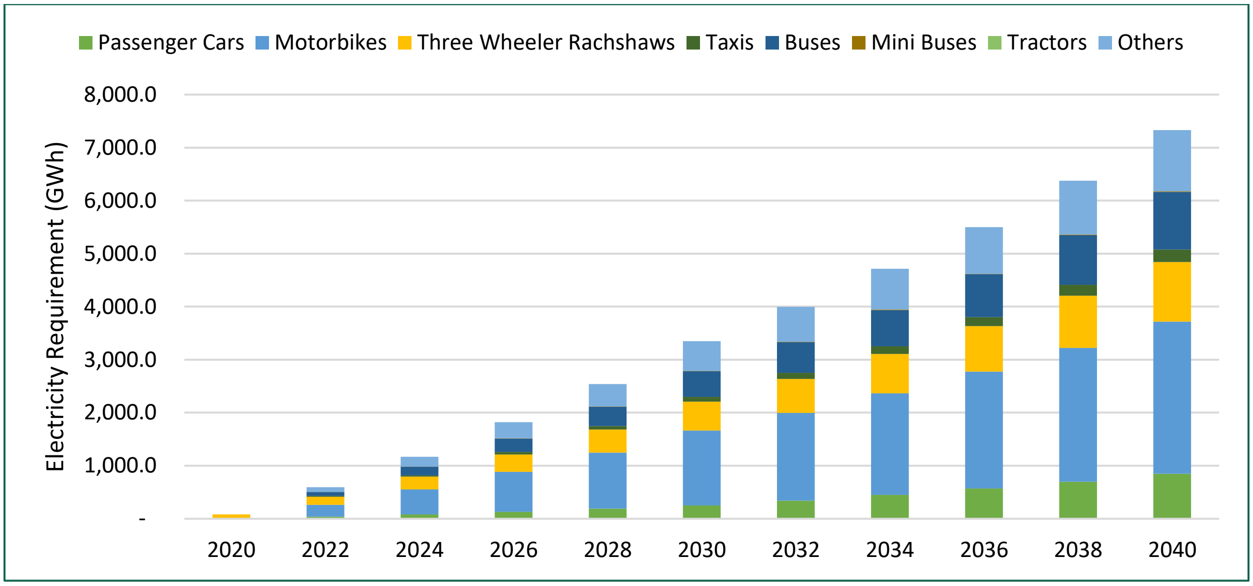

Figure 47 Electricity Requirement in Passenger Road Transport in EPS

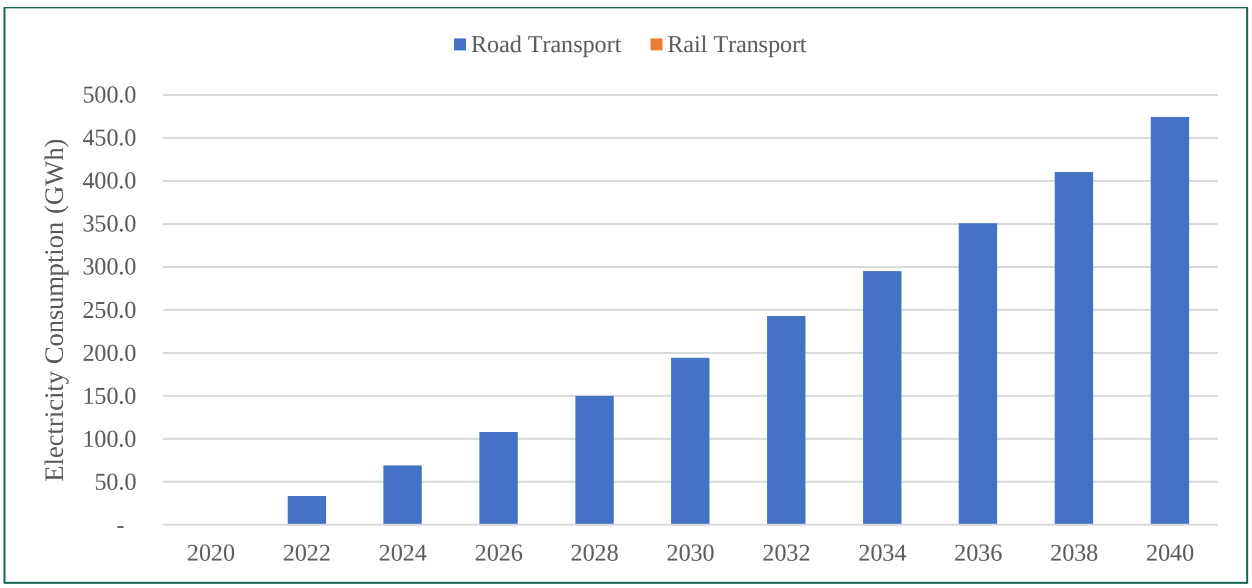

Figure 48 Electricity Requirement in Freight Road Transport in EPS

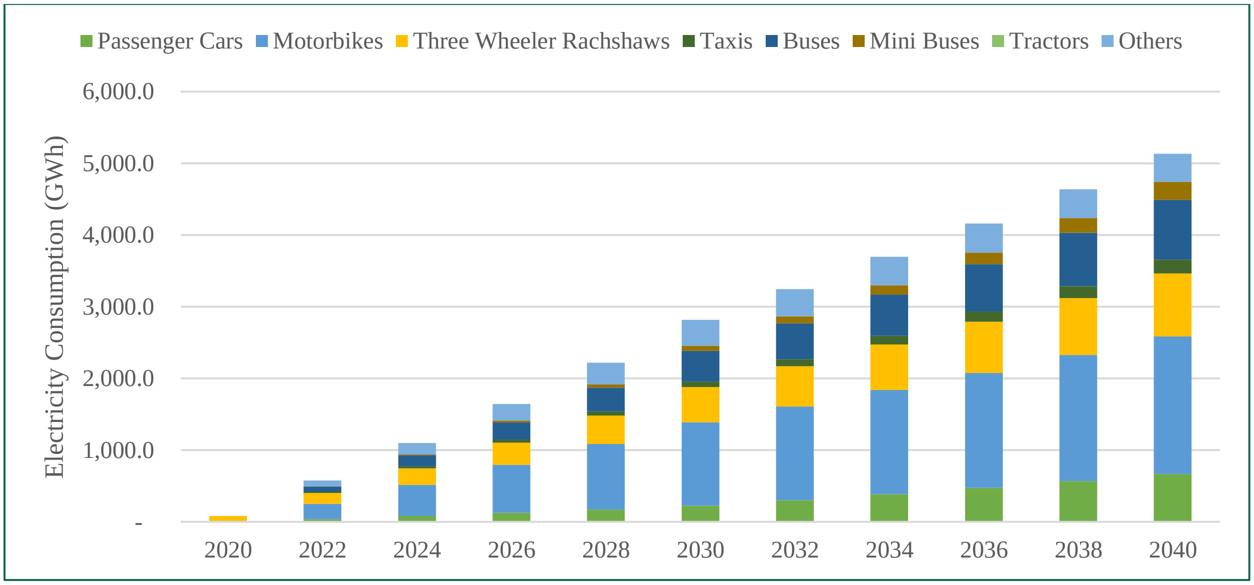

Figure 49 Electricity Requirement in Passenger Road Transport in ENE

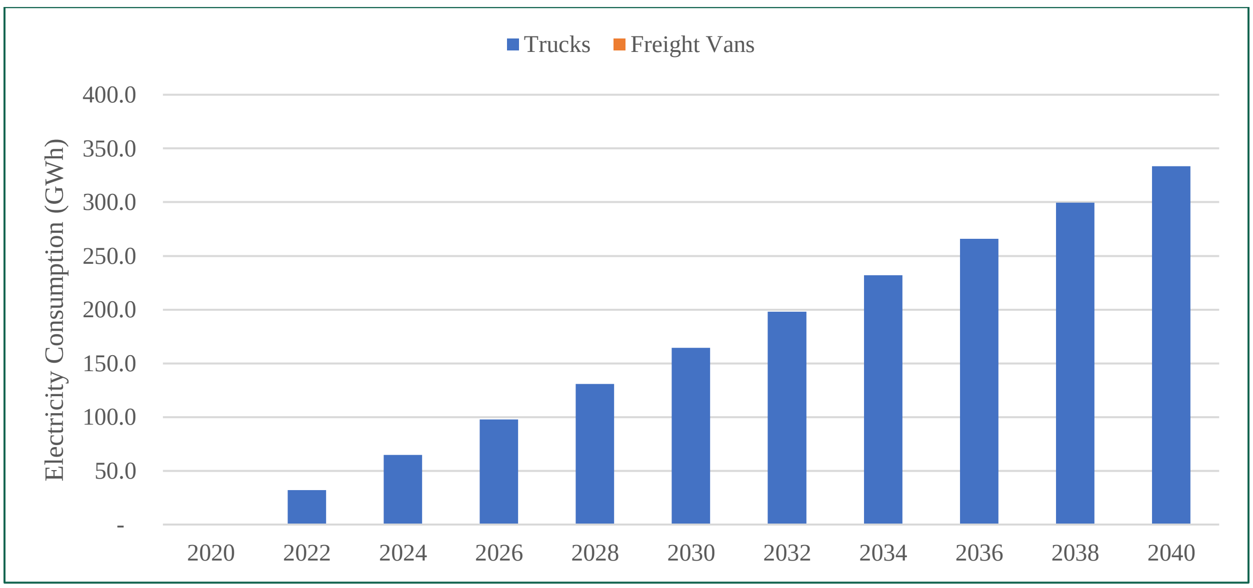

Figure 50 Electricity Requirement in Freight Road Transport in ENE

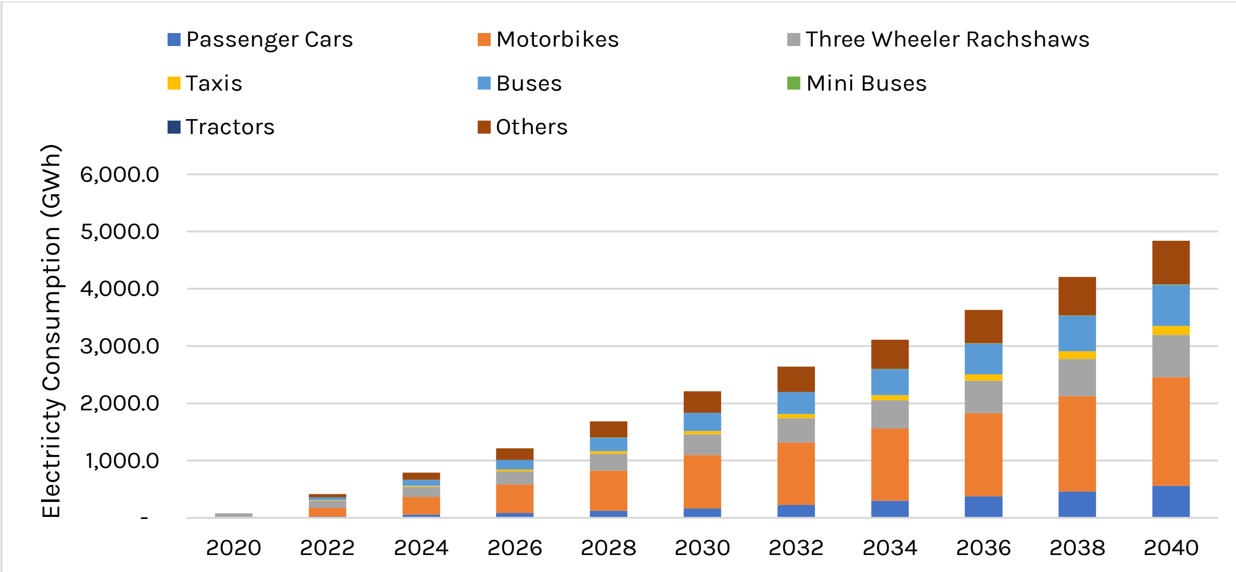

Figure 51 Electricity Requirement in Passenger Road Transport in SGS

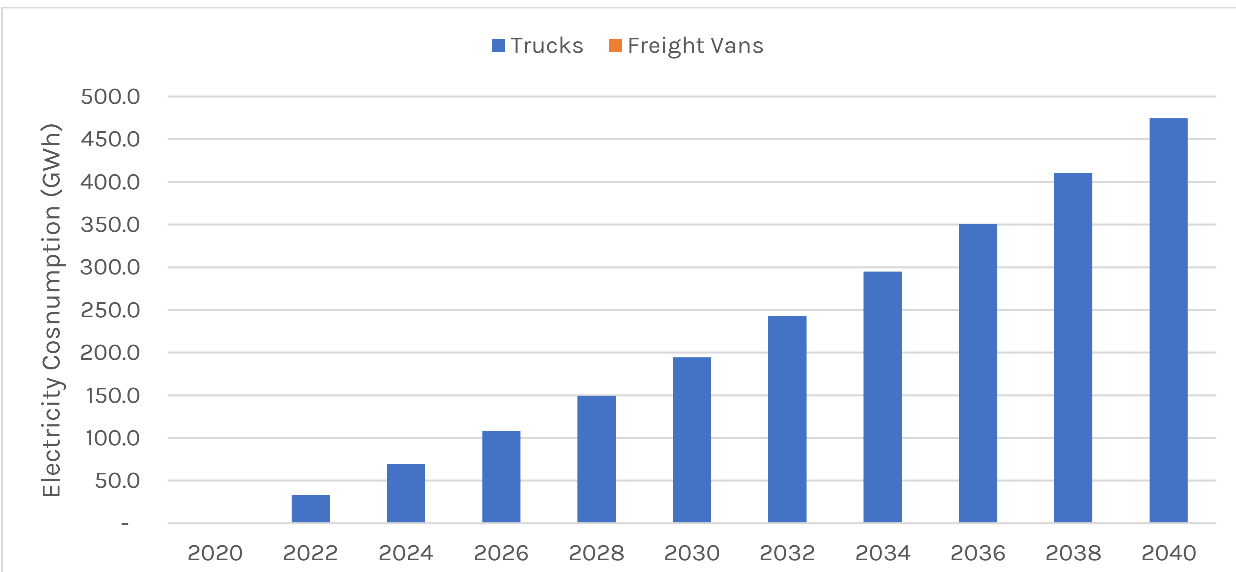

Figure 52 Electricity Requirement in Freight Road Transport in SGS

Annexure 6: Emissions from Different Transport Subsectors in the BAU Scenario

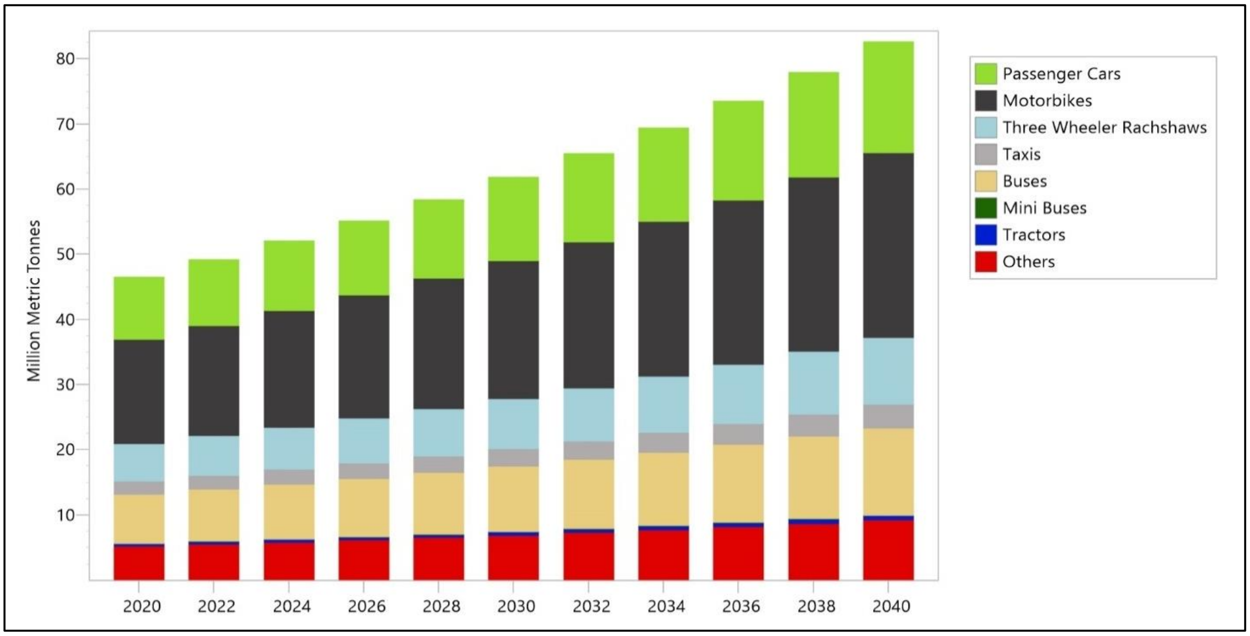

Figure 53 Emissions from Passenger Road Transport in the BAU Scenario

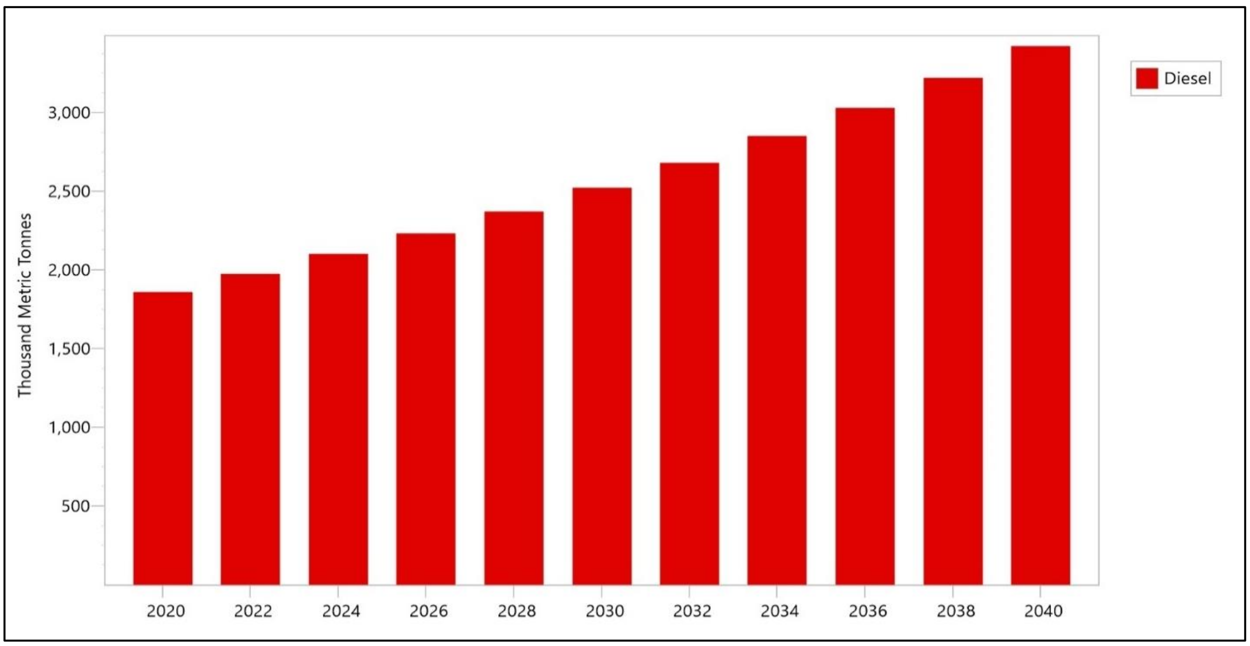

Figure 54 Emissions from Passenger Rail Transport in the BAU Scenario

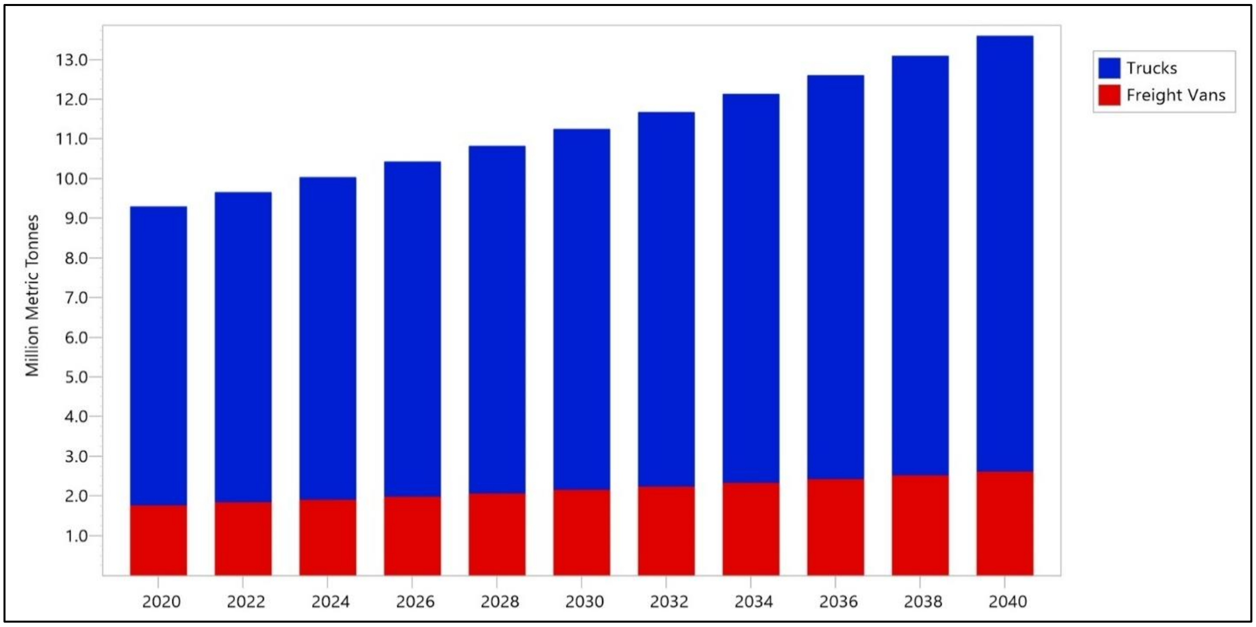

Figure 55 Emissions from Freight Road Transport in the BAU Scenario

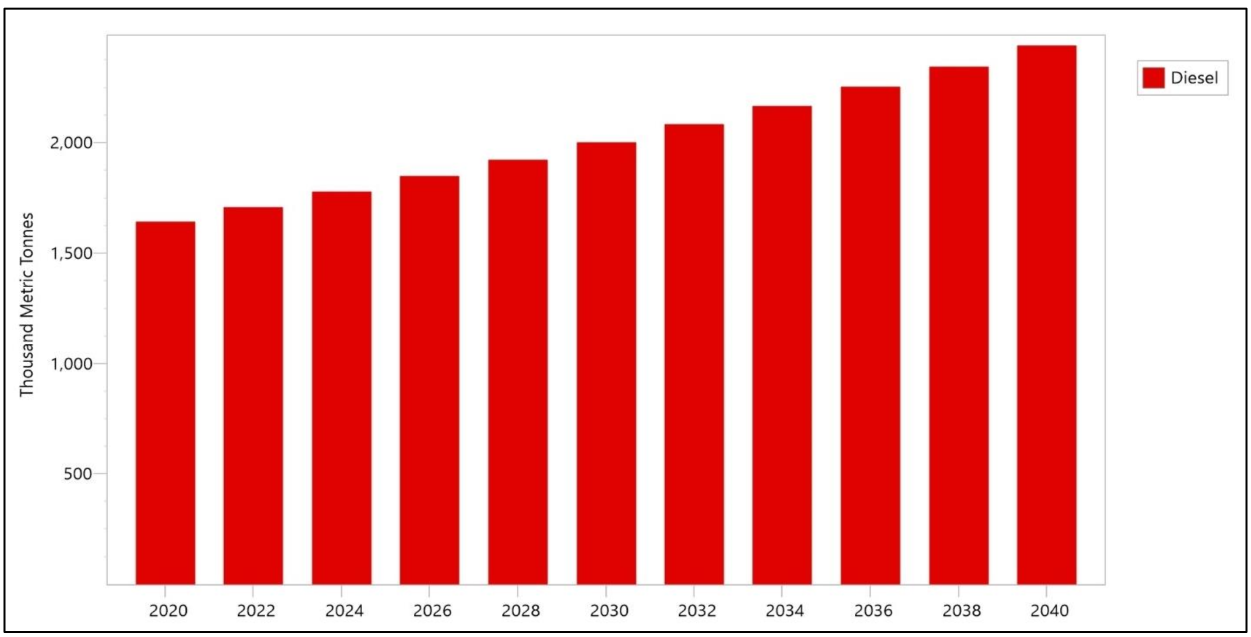

Figure 56 Emissions from Freight Rail Transport in the BAU Scenario

Annexure C: Agenda of Stakeholder Consultation on "Market Preparedness and Policy Support for Electric Vehicles (EVs) in Pakistan"

25th May 2022 | 10:00 AM to 12:00 PM (Pakistan Standard Time) | Online

Zoom Link: https://us02web.zoom.us/webinar/register/WN_mygtu5-fR_6IWS7perXZDg

Time	Agenda Point
10:00 – 10:05	"Welcome/Opening Remarks" by SDPI.
10:05 – 10:10	"Agenda Setting" by **Dr. Hina Aslam**, Head, Energy and China Study Centre, Sustainable Development Policy Institute (SDPI), Islamabad.
10:10 – 10:40	**Keynote Addresses** • **Dr. Naveed Arshad,** Associate Professor, Lahore University of Management Sciences (LUMS). • **Dr. Irfan Tariq,** Director General (Env & CC) [Ex], Ministry of Climate Change, Government of Pakistan.
10:40 – 11:30	**Panel Group Discussion** • **Dr. Tanvir Ahmad,** Project Manager-Energy, United Nations High Commissioner for Refugees (UNHCR) • **Mr. Khalil Raza,** Energy Efficiency Consultant, The World Bank Group • **Mr. Sabir Jamal,** Secretary, Federal Board of Revenue (FBR) • **Mr. Ahmed Sajeel,** Regional General Manager-North, Dewan Motors (BMW Group) • **Ms. Komal Kareer,** Analyst, BloombergNEF • **Ms. Nupur Shah,** Founder Sustainbhoomi and EV Consultancy Moderator: **Dr. Hina Aslam,** Research Fellow and Head, Energy and China Study Centre, SDPI
11:50 – 11:55	**Moderated Q&A Session**
11:55 – 12:00	Concluding Remarks.