UNDERSTANDING PUBLIC MOBILITY TO DESIGN A GREEN TRANSPORT SYSTEM FOR ISLAMABAD

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CERTIFICATE

This is to certify that this thesis entitled: **"Understanding Public Mobility to Design a Green Transport System for Islamabad."**. submitted by **Farzana Rubab** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in MPhil Environmental Economics.

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Declaration

I__Farzana Rubab__hereby state that my MPhil thesis titled "Understanding Public Mobility to Design a Green Transportation System for Islamabad" is my own work and has not been submitted previously by me for taking any degree from Pakistan Institute of Development Economics or anywhere else in the country/world.

At any time if my statement is found to be incorrect even after my Graduation the university has the right to withdraw my MPhil degree.

Signature of Student

Date: May 10, 2023

(F.R)

Farzana Rubab

Dedication

To my parents

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Abstract

The transportation industry in Pakistan is growing rapidly which in turn has raised the cost of energy imports, usage of petroleum products, air pollution, and traffic congestion. It is perturbing that the world is too much dependent on fossil fuels to meet its energy requirements. In order to address energy, economic and environmental problems of any nation, electrification of road transportation appears to be a game-changer. The aim of this study is to help implement a green transportation system in Islamabad and Rawalpindi. This study compares the financial and environmental costs of using electric, diesel, and solar buses. It also assesses the viability of using suitable electric vehicles (EVs) for Islamabad and Rawalpindi's public transit systems and considers several technological choices.

Electric vehicles (EVs) provide a solution to these problems. Hence, switching from fossil fuel vehicles (FFVs) to EVs is a necessary step in decarbonizing the country's transportation sector and reversing its dire socioeconomic situation.

In this study, the applied quantitative and qualitative analysis forms the foundation of the primary research design as we examine the energy usage and consumption in Plug-In Electric Vehicles (PEVs) for the current private services in Islamabad and Rawalpindi. In this paper, socio-environmental and financial comparison among FFVs, EVs and Solar buses have been evaluated.

The study's findings indicate that solar buses use only 18% energy as compared to electric buses which use 30% while diesel buses use 52% for same seating capacity and same distance covered. However, batteries powered buses are currently more expensive than diesel buses. Although it costs more than diesel buses, using electric and solar buses is beneficial for both human and the environment.

1 INTRODUCTION

1.1 Background:

Traffic congestion can be determined by looking at the pattern of developing and underdeveloped nations. According to studies, a society's economy and special activities are hampered by traffic congestion. The lack of an active non-motorized transportation system is another element that these emerging nations have in common. Yet, the number of private vehicles is growing over time. Because poor transportation systems simultaneously cause noise pollution and air pollution, they pose a danger to environmental quality (Jain, Sharma et al. 2012).

The transport sector contributes greatly to an economy's expansion by linking numerous economic sectors. Along with playing a positive role, it also significantly contributes to the global pollution caused by use of fossil fuels. As indicated by (Staff 2012), transportation discharges include 25% of world fossil fuel byproducts, which is 71% more than that of outflows in 1990s. Additionally, oil accounts for 93 % of all transportation energy use (Raturi 2019).

Pakistan's pollution statistics present a grim picture. Due to the extensive growth of the county's transportation networks, an estimated 47.2 percent of petroleum products are in demand. As a result, the average vehicle in Pakistan emits 25 times the amount of carbon dioxide as the average vehicle in the United States(Channa).

As a result of the transportation sector's excessive reliance on petroleum derivatives, which also contributes to environmental change and the unfavorable rise in global temperatures, managing green transportation is arguably one of the most difficult challenges faced by the modern society (Balsalobre-Lorente, Driha et al. 2021). Street transportation is considered as the main supporter of outflows among the various vehicle modes. The aviation area is the main backer of transportation after mass transit. Yet, because they alter the climate at great altitudes and degrade the quality of nature at the surface, aviation sector outflows are even more hazardous to the environment.

Transport plays an important role in urban development by providing masses the accessibility to workplaces, education, recreational sites. Specifically, for the developing countries to provide affordable transport system(Ali, Socci et al. 2018). Societies with better transportation infrastructure merge all economic activity into one. More integrated economic activity result from a better organized transportation infrastructure. A common characteristic of nations with good development indices is a developed transportation infrastructure (O'Neill, Coney et al. 2020)

While most of the emissions. in addition are released near to the surface, the remaining half are carried over a height of 6,000 feet (Uherek, Halenka et al. 2010). That is why the world needs a better sustainable transportation system which can contribute to the environment and society.

1.2 **Transport Sector in Pakistan**

The primary source of financial growth and development is thought to be the transportation sector. 10% of the GDP and 6% of the country's new business prospects are attributable to Pakistan. This area connects numerous economic sectors through the growth of agglomerations, the expansion of crossline and public trade, and the facilitation of spatial transformation. Due to the inefficiencies of the present vehicle and strategy framework, the Pakistani economy loses 4-6 percent of GDP each year, which is crucial for the health of the economy as a whole (Sánchez-Triana, Afzal et al. 2013). Pakistan also ranks the global rankings for being open to environmental issues. Climate change is anticipated to have unfavorable impact on Pakistan. This is peculiar for a nation, which ranks 135th in the world in terms of global greenhouse gases (GHG) emissions per capita but ranks 16th in terms of vulnerability to climate change (Khan, Khan et al. 2016). A green transportation framework is urgently needed since it contributes significantly to environmental quality.

Due to various factors, Pakistan's transportation industry is growing at a double-digit rate. With 64% of the total population under 30 years of age, the country has the highest proportion of youth in the world. The population of the entire country is growing at a 2.1% annual rate. Pakistan is also undergoing fastest urbanization among South Asian nations; by 2025, the country's metropolitan population is anticipated to reach 60% (Ullah 2019).

Many issues with Pakistan's transportation system have various impacts on the country's energy and environmental issues. For instance, rail route transit rated as the main means of transportation throughout Pakistan's entire history. Prior to declining to 4% in 2011, it handled 73% of cargo transit during its peak between 1955 and 1960. Between 1991 and 2011, it reduced the length of its track by 11%, or from 8875 to 7791 km. Moreover, from 84.9 to 58.9 million passengers were transported overall during the same period, a 31% decrease (O'Neill, Coney et al. 2020). In 2019–2020, there were 39.4 million fewer travelers.

Another test for Pakistan's automotive industry is the use of high-sulfur fuels in the automobiles. The bulk of Pakistan's power plants have Sulphur levels between 5000 and 10,000 parts per million. The Euro III and Euro IV outflow guidelines are considerably exceeded by this sum. These Euro III or IV standards have been accepted by some South Asian nations. The appropriation interaction is typically delayed in Pakistan for a variety of reasons.

Transportation is believed to be Pakistan's second-largest energy user. As much as 97 percent of energy is derived from petroleum, and up to 28 percent of its energy mix is biased towards conventional sources.

Pakistan's energy-related CO2 emissions grew due to the amount of energy needed for transportation-related activities from 68,242 (kt) in 1991 to 166,298 (kt) in 2014 (Majeed and Tauqir 2020).

The transportation industry globally emits 22% of greenhouse gases, a number that is expected to increase by 1.75 times by the year 2035 (Channa).

Pakistan's ineffective and costly public transportation infrastructure has led to a development in the private transportation industry. Also, as its working class expands, private automobile demand has been steadily rising (Rasool, Zaidi et al. 2019).

Yet, employing environmentally friendly transportation strategies can aid in resolving the issues with the current transportation system. Implementing green transportation systems is one of the best methods to reduce oppression and meet the mobility needs of the steadily growing urban population, even though developing routes is not an option. Green transportation is an essential part of the sustainable development goals, which have been created over time by different experts. It can be summed up as "any form of transportation that takes into account people and offers a variety of safe, affordable routes of transportation."

Green transportation also has a negligible influence on the environment because it only uses energy that is either renewable or recycled, as opposed to fossil fuels-based vehicles like electric Bicycle, Auto Electric Sky Trains and Electric Motorcycles. The main contributors to the green energy transportation are vehicles with multiple occupants (which decreases the demand for more vehicles) and hybrid vehicles, among others (Pamuła and Pamuła 2020).

1.3 **Introducing Green Transportation in Pakistan:**

Green transportation promotes a healthy and ideal way of living in addition to being an environment friendly or low-carbon method of transportation. Green transportation system development is advantageous for the efficient use of route resources for ease of over trafficking, the reduction of energy consumption, the reduction of over emissions, and finally it will minimize GHGS emissions.

Pakistan is one of the country's most vulnerable to climate change because it is primarily fueled by pollution. Due to significant Green House Gas (GHG) emissions, it is ranked as the third worst country in the world in the Global Air Quality Index Report 2022.

The recent data from the Pakistan Bureau of Statistics (PBS) show that recorded oil imports for the July to October period of 2020–21 were $3.15 billion, demonstrating that the usage of fossil fuels is harmful to both the environment and the economy.

China and Japan are excellent examples of green travel, where high timeliness and performance flexibility are essential building blocks. It serves as a crucial component of integrated urban transportation and is the ideal mode of transportation for short-distance travel and transfer. In summary, developing green transportation significantly affects energy conservation, reducing carbon sequestration and PM2.5 emissions and enhancing the environment(Hua-pu 2009).

Climate challenges can be resolved by introducing EVs. EVs don't use fuel; instead, they run on electricity. EVs don't emit harmful contaminants in this way. Hence, replacing FFVs with EVs can significantly reduce the release of toxins which can aid to enhance the environment for decomposition. Suburban EV drivers will pay a hefty sticker price for each unit of power purchased from the government. The public authority can coordinate the amount for limit installments and generate a sizable money in this approach. Knowledge of EVs is certain to bring several other economic advantages. By drastically reducing gasoline imports, EVs will mitigate the growing import/export imbalance. The integration of EVs into the transportation system may create a completely new industry in Pakistan, opening a variety of economic opportunities and strengthening the nation's economy (Todoruț, Cordoș et al. 2020).

For the transportation sector, the energy input from fossil fuels is essential. Total transportation energy increased from 23% in 1971 to 29% in 2017. Moreover, oil accounts for 93% of all transport energy. Because the transportation industry is so dependent on fossil fuels and contributes to climate change and the difficulties related to global warming, dealing with green transportation is one of the most urgent issues facing the modern world(Sánchez-Triana, Afzal et al. 2013)

Road transportation is cited as the primary source of emissions among other modes of transportation. Following that, the aviation industry is the primary source of emissions (Bahadır 2022). Transport and industry make up the two major energy-using sectors in Pakistan. The energy mix is strongly biased in favor of traditional techniques since roughly 28 percent of the energy, which is derived from fossil fuels, is used for transportation(Sánchez-Triana, Afzal et al. 2013).

1.4 **Problem Statement:**

For places like Islamabad and Rawalpindi, where urban expansion and development have led to increased population and land use, the risk of environmental degradation and climate change is a question of time given the high speed of technological innovation, industrial development and urban growth. These cities are growing rapidly and as they do, so do their needs for decent housing, decent educational facilities and decent transportation.

This study examines the lack of a transportation system in Islamabad and Rawalpindi, which are cities with at least minimal green and sustainable transportation policies in place. The Pakistani government has implemented Bus Rapid Transit (BRT) systems like Metro Bus Service to meet the country's rising demand for public transportation but did not properly calculate the environmental cost. These BRT initiatives didn't even account for long-term green goals to move from fossil fuel to electric vehicles. The goal of this project is to develop a replacement system for running the current transportation services in Islamabad and Rawalpindi that is based on an environmentally friendly and sustainable transportation system.

As a result, this study will gather information and compare the cost of an electric vehicle for the same project to an FFV that is now in use in Islamabad/Rawalpindi. The study will present the financial, social, and environmental costs of both FFV and EV. The alternative (EV) should also be able to provide all the specific operational and functional needs, such as charging stations, mileage, storage, and consumption.

1.5 Objectives of the Study:

1) To analyses the mobility trends in Rawalpindi and Islamabad and propose mass transit routes for the twin cities.

2) To estimates the investment that would be required to establish an EV base mass transit system for the twin cities and compare it with the financial, economic and environmental cost of same system when operated on fossil fuels.

1.6 Significance of the study:

Many less developed nations are experiencing network issues and growing costs of living because of rising temperatures. An increase in Greenhouse Gases (GHG) is undeniably connected to an increase in temperature because of several anthropogenic and non-anthropogenic activities. There has been a considerable change in temperature during industrialization. GHG emissions have increased due to industrialization, surpassing all prior records from the previous 100 years and going beyond the point of no return. After industrialization, there has also been an increase in demand for transportation of goods from the point of manufacture to commercial hubs and to the doorsteps of customers all over the world. Yet, transportation is also essential for many economic and non-economic activities, which also produce significant amounts of CO_2.

Bangladesh, a relatively underdeveloped country to Pakistan, has started taking moves to electrify its nation's roads. To promote EV growth, Bangladesh's Ministry of Industry has created the Automobile Industry Development Policy 2021. By 2030, the subject policy aims to transition the majority of goods used in public transportation to electric vehicles.

The 10-year tax vacation, financial incentives, buying subsidies, road tax waiver, duty cuts incentives for setting up battery recycling industries, and networks of charging stations have all been suggested by Bangladesh's ministry of industry. In addition, this policy recommends creating a "Energy-Efficient Vehicle Manufacturing Fund" into which fines and taxes on automobiles that pollute the environment will be put.

In Pakistan's transportation sector, a few solutions have been identified to reduce emissions by switching to alternative fuels because of their potential to reduce greenhouse gas emissions, benefits from economic growth and affordability. The vehicle offices include passenger cars, cabs, vans and trucks. CNG, diesel, gasoline and solar energy will replace current fuel sources.

On Prime Minister's directives, Ministry of Climate Change developed Pakistan's first National Electric Vehicle Policy (2019). The Policy suggests a strengthened and tiered approach for achieving the infiltration goals for electric vehicles in three stages, including market improvement and public awareness, the substitution of fuel import charges, neighborhood reception, and fare. Across the globe, EVs are dominating the automotive sector. In Pakistan, the transportation sector has experienced two-digit growth.

Almost all facets of transportation rely on petroleum-derived products, and the nation spends close to USD 13 billion on oil imports each year. The price of importing oil is anticipated to climb in the following years if the market for vehicles keeps expanding at the current two-digit rate. The country would likely face serious challenges in the next years because of the triple blow of rising fuel tax installments, unavoidable corruption, and limit tax installments. It is widely acknowledged that introducing EVs into the nation, with the appropriate strategic system, will not only improve the aforementioned concerns but will also lead to job creation and economic growth in the nation(Ullah 2019).

Although the National Electric Vehicle Policy is something to be grateful for, especially for the environment, work on this plan has not yet begun. This configuration is for all types of vehicles, including trucks, cars, and buses, but in Pakistan, only initial work on electric vehicles has been done. As we are aware, electric vehicles are more expensive than conventional vehicles, and only a small percentage of people can afford them. Therefore, on the off chance that we offer EVs as open vehicles and operate electric transports for public vehicles, it will be beneficial for both our nation and sustainability.

2 LITERATURE REVIEW

2.1 EV Transportations from Global perspectives:

Most of the time, transportation and infrastructure projects are highly capital intensive and need enormous financial resources. Open assets are primarily used to fund these enterprises. On the one hand, the use of public resources for these activities raises concerns about the potential costs of restricted resources, while on the other hand, there are persistent concerns about devaluations, commissions, and payoffs being connected to the completion of these initiatives(Correa Perelmuter, Muñoz et al. 2017). Due to the unfortunate shortcomings of honesty, more flimsy management, and responsibility, these problems are more severe in agricultural nations compared to the industrial nations. The use of advantage cost analysis is the traditional way to justify the financial resources for capital major transportation and framework projects.

Jules Dupuit first developed this tactic in 1848 while working on a development project(Sandmo 2011). Interestingly, the United States used the benefit cost investigation in the Harbors Act of 1899(Hyard 2012). Benefit cost analysis has consistently developed into a crucial tool for analyzing and assessing the financial viability of projects, particularly those that involve public funds.

Depending on the amount of information required to calculate a task's costs and benefits, conducting a money-saving advantage research can be a costly and complex task(Tie and Tan 2013).But this particular writing review is a brief summary of some of these insightful works that are primarily focused on transportation area projects.

There has been extensive writing on the usage of the advantage cost examination for financial viabilities of the public area projects. Because of the extremely high levels of air pollution in many parts of the world and the numerous unanticipated deaths that result from consistently poor air quality worldwide, air quality has an impact on human health. Vehicle outflow is one of the most important aspects of the current situation, along with a change in global temperature (OECD 2016). The transportation sector may have the greatest effects on ozone-depleting gas (GHG) outflows since conventional vehicles that only use internal combustion engines consume a lot of petroleum byproducts. They also release chemicals into the natural environment, such as carbon dioxide, hydrocarbons, and nitrogen oxides (Tie and Tan 2013), which affects human health and safety as well as the global climate. Environments and animal habitats, as well as the use of common resources, have an impact on these international relationships (Jacobson 2009).

Global oil production declines and strenuous environmental measures are anticipated to lead to new, clean transportation breakthroughs (Delprat, Lauber et al. 2004). To address these environmental and energy issues, hybrid electric vehicles—which only use the pass cycle seen in completely electric vehicles—and fully electric vehicles themselves have undergone advances over the past ten years. Although these cars are undoubtedly more energy-efficient than typical cars, the aim of vehicle development is to create entirely electric cars. 2019 (Li, Khajepour et al. 2019). Due to its many advantages, including zero outflows, electric vehicles are now available for public transportation in a rising number of urban areas throughout the world.

Outstanding automobile the majority of people believe that public transit is manageable, but using traditional automobiles and modes of transportation is unsustainable and bad for the environment (Lajunen 2014). The use of electric automobiles and/or transportation is a respectable, eco-friendly, and enduring arrangement. This section discusses tests related to electric and alternative transportation advances in the writing.

The writing demonstrates electric transport innovation in terms of transportation planning and writing on several standards dynamics in transportation is also provided. (Kitthamkesorn and Chen

2017) Explain how creating a sustainable transportation system depends on lowering car emissions. A sensible and effective method for lowering transportation costs and financing improved travel options is elevating inexperienced transit options. The authors of this study use a disorderly weibit-based model to tackle the combined modal split and traffic work (CMSTA) problem. Their model openly considers similarities as well as various insight modifications under mobbing. Instead of extending the commonly known Gumbel circulation, the technique and direction suggestion findings derive from random utility theory using Weibull distributed random mistakes.

A nested weibit (NW) model is developed to reduce the matching observation variance of the logit model at the level of approach proposal. The recently developed path-size weibit (PSW) is unable to manage overlapping at the level of direction recommendation as well as route-specific perception variance. Also, a corresponding Mathematical Programming (MP) invention is developed for this NW-PSW model as a CMSTA problem for overfilled systems.

A few components of the projected models have also undergone thorough evaluation. To study (a) the behavioral modelling of travellers' mode shift between private motor-powered and go-green modes and (b) travellers' route suggestion with consideration of both route overlapping and non-identical perception variance, various go-green approaches are quantitatively estimated using this disorganized weibit-based NW-PSW model. The results show that the NWPSW model is substantially more capable of major replication of modifications in model parameters and linkage features than the classic logit and extended logit models(Enang and Bannister 2017).This study uses indicators to estimate the improvement made by Italian cities in the smart movement area, thus recognizing how these cities have loomed the new strategies executed by the European Union, and how they have been executed the European deviations.

Precisely, this work examines the development of communal transport systems, consuming a model of twenty-two Italian cities for three consecutive periods 2005, 2010, and 2015. The results recognized are then related to the subsidy provided for the operation of projects associated with smooth mobility in the cities deliberate, in demand to prove conceivable correlations between the progress of these amenities and European and countrywide monetary savings. The data wringer illustrates notable progress in the ground of sustainable movement, specifically between 2010 and 2015 as well as how this improvement is related to the substantial monetary support that helps the understanding of tasks connected to smooth mobility.

Different investigations exist regarding the techno-monetary and ecological effects of electric transports. Kühne talked about the energy qualities of electric battery streetcars in his audit(Kühne 2010) study researched the energy productivity of electric transports utilizing an energy utilization model(Lin, Wu et al. 2013). McKenzie and Durango-Cohen discussed elective energizes as far as life-cycle evaluations of cost and ozone depleting substance outflows(McKenzie and Durango-Cohen 2012). Cooney and Kliucininkas explored the impact of possible GHG emanation decreases from electrical transports on the climate(Nurhadi, Borén et al. 2014).

2.2 **Alternative Bus Technologies and Electric Buses Regional Level:**

Populations have increased throughout developed and agricultural countries, with transportation becoming a major concern in emerging metropolitan centers. Neighborhood organizations are empowering public transportation frameworks to produce an answer for this issue. Considering this support, administrations with more current, conservative, and mechanical frameworks have been given. Due to their lower emissions and other social and financial benefits, an increasing number of urban towns now use electric vehicles for public transit. Every year, there are more and more electric vehicles in use around the world(Staff 2012). Scholastic writing has filled because of the present circumstance and the improvement in innovation. Lately, expanded EV-related exploration has been directed(Yao, Liu et al. 2020)

Nurhadi inferred that short-term battery-electric vehicles were ideal in terms of cost- adequacy (Nurhadi, Borén et al. 2014). Lajunen zeroed in on the money saving advantage examination of executing electric transports on the way in his financial investigation (Lajunen and Lipman 2016). Ribau advanced activity for elective powertrains (Ribau, Viegas et al. 2014).

Li led a survey of operational and innovative requests for battery-operated-electric vehicles. Miles and Potter, Filippo et al., Chao and Xiaohong, and Zivanovic and Nikolic talked about the operational limitations of electric transportation(Nikolić and Živanović 2012). Mahmoud et al. introduced a survey of electric transport innovations in the travel setting and focused on three aspects, in particular, cross breed, power module, and battery (Mahmoud, Garnett et al. 2016).

Besides, Lin et al., Wang et al., and A contemplated electric bus charging foundation arranging and plan (Lin, Wu et al. 2013). Lajunen and Lipman contemplated lifecycle cost appraisal(Lajunen 2014). Rogge et al. considered battery EV booking (Gabsalikhova, Sadygova et al. 2018). Schneider et al. examined electric vehicle (EV) battery charging and buying enhancement (Miao, Hynan et al. 2019).

Brendel et al. what's more, Xu et al. contemplated EV-based vehicle sharing framework improvement. Gao et al. contemplated battery limit and re-energizing (Delprat, Lauber et al. 2004). Krause et al. taken a gander at EV use potential (Krause, Ladwig et al. 2018). Wang et al., Erdo ˘gan and Miller-Hooks, said et al., and Yang, et al. considered the enhancement of course decisions. Contemplated life-cycle benefits concerning energy utilization and carbon dioxide outflows(Luo, Gu et al. 2018). Sun et al. seen quick charging station decisions and practices(Sun, Yamamoto et al.

2016). At last, Panchal et al. contemplated debasement testing and battery displaying (Panchal, Gudlanarva et al. 2020)and the plan and reproduction of batteries.

2.3 **Electric Vehicles from Pakistan Perspective:**

The ratio of this type of vehicle's creation to sales is growing as a result of Pakistan's burgeoning population. For example, cabs run on CNG or gasoline. Buses and vans frequently run on petroleum or diesel, trains typically run on coal, oil, or diesel, while neighboring rickshaws typically run on CNG or fuel. Public motorways and common highways total 13,000 and 93,000 km each, with other areas, common areas, and city roads filling in the remaining distances(Asghar, Rehman et al. 2021). Due to the development of the ambitious China Pakistan Economic Corridor (CPEC), which is currently building 3070 km of new road and railway routes, this transportation system is expanding. Although the shipping lane will be improved, the current roadway network will be overloaded.

In comparison to the previous fiscal year, the population increased from 208.57 to 212.48 million people in 2020–21, and the share of the street transport area increased as well(Rasool, Zaidi et al. 2019). According to statistics, there are 16 vehicles on average per 1000 people, a number that is certain to rise as Pakistan pushes for rapid urbanization. According to the 2018 review, almost 17 million vehicles were enrolled; by 2025, that number is projected to rise by 30 million. As of 2018, the transportation sector was using nearly 302,000 barrels of oil per day; by 2025, that number is projected to rise(Asim, Usman et al. 2022).

Oil imports were significantly reduced till 2016 despite Pakistan's long-standing, heavy reliance on oil imports. Pakistan's heavy reliance on oil imports has existed for decades, but as gas use rose in the 1990s, imports of oil were significantly reduced. Due to a shortage of natural gas supply and a decline in global oil prices, our country resorted back to oil in 2017. Most of the Pakistan's road transportation today depends on oil and gas. Because the transportation sector is interwoven with so many other businesses and uses so much gas, oil imports were significantly reduced until 2016. Due to a shortage of natural gas supply and a decline in global oil prices, our country resorted back to oil in 2017(Jaffery, Khan et al. 2014).

According to the LUMS EV Report, Pakistan is one of the major countries impacted by environmental change because of liquefying ice masses, floods, heat waves, dry seasons, and dense smog that covers the majority of Sindh and Punjab throughout the winter.

A hybrid electric vehicle was also recommended by a Pakistani study based on its consumption and carbon emissions. It was determined that HEVs can operate with emissions decreased by a factor of 25–30% annually and can save up to 40% on gasoline. In that approach, Pakistan can readily anticipate putting EVs into use by 2030, as the current administration has intended (Khan, Ali et al. 2020). Since the use of EVs has not yet reached its full potential, numerous studies have attempted to concentrate on a particular EV that may be advantageous for a certain nation.

2.4 The impact of electric vehicles adoption on the greenhouse gas emissions:

Numerous research on the environmental advantages of EV adoption have shown an important association between these advantages and the energy sources used to produce both the batteries and electronic components that go into manufacturing vehicles as well as the energy needed for running those vehicles(Hoekstra 2019).

In context of this, some writers have suggested evaluating the environmental feasibility of EV adoption while avoiding overestimating or underestimating emission parameters (Hawkins, Singh et al. 2013, Hoekstra 2019, Pipitone, Caltabellotta et al. 2021) by considering both the energy consumption during the production process and the energy utilized by vehicles on the road. When the effects of ICEVs and BEVs on GHG emissions were calculated over the course of their respective life cycles, it was discovered that a BEV released 109.6 g/km of CO2eq during production and use, which is 41.4% less than an ICEV.

(Costa, Barbosa et al. 2021) estimated a BEV and an ICEV that had similar components, employing a similar approach. These authors examined the GHG emissions produced during the production of both vehicles and discovered that the ICEVs emit more GHGs than the BEVs, attributing this finding to the larger number of components that must be produced for an ICEV as opposed to a BEV; however, this environmental benefit depends on the energy mix.

Consistent with this, (Siragusa, Tumino et al. 2022) used the LCA to estimate the GHG emissions, considering the complete life cycle of a vehicle (raw material and component acquisition and processing, maintenance, and disposal). According to these authors, switching to EVs can reduce greenhouse gas emissions by 17 to 54% depending on how many miles are driven.

Vehicle emissions make a significant amount of air pollution along with industrial emissions. The number of vehicles on the road and the number of miles travelled have both had a dangerous effect on Pakistan's air quality. The country's extensive road system contributes to a high demand for petroleum products, which accounts for 47.2% of all petroleum products produced and imported; additionally, the fleet's approximately 50% of older vehicles results in incomplete combustion, which increases the amount of hazardous emissions into the atmosphere (Khwaja 2005).

An average vehicle in Pakistan releases 25 times more CO2 and 20 times more nonmethane hydrocarbons while 3.5 times more Sulphur dioxide than vehicles in the United States (Barber 2008).

In the capital Islamabad, the intensity of CO_2, NO and SO_2 and PM2.5 have exceeded the levels set by Pakistan National Environmental Quality Standards (NEQS)(Bilal, Mhawish et al. 2021).

The Push-Pull and Mooring (PPM) framework used to investigate the switch intentions of people from conventional vehicles to green vehicles in the perspective of smog. The results showed a positive impact on switching intentions towards green vehicles of smog knowledge, perceived environmental health risk, choice self-efficacy, willingness to pay, and alternative attractiveness. In parallel, switching intentions are not much impacted by the normative or regulatory environment. Push and pull factors also have a substantial moderating impact with the interaction of mooring aspects on shifting intentions. It can conclude that mooring and push-pull factors may help people shift to green vehicles. In order to reduce smog pollution in Pakistan, it might be beneficial to move from motorized to green vehicles as a result of these reasons(Anwar, Hussain et al. 2022).

2.5 **Economics feasibility of Electric Vehicles adoption:**

When analyzing the economic viability of adopting BEVs to ICEVs, some studies have indicated that the purchase price is the most important aspect, with high cost being one of the key obstacles delaying the adoption of EVs(Gomez Vilchez, Smyth et al. 2019).

The high cost of the batteries, which accounts for 75% of the total cost of the vehicle, is the cause of its high pricing. This is mostly because electrodes, which require valuable elements, are expensive and 60–80% of the whole cost is made up of raw materials(Berckmans, Messagie et al. 2017).

(Neubauer and Pesaran 2011) proposed that giving batteries a second chance can reduce the cost of EVs and boost interest in them in light of this. By examining consistency and ageing traits and speculating on potential uses, (Jiang, Jiang et al. 2017) suggested a new screening technique to evaluate the ageing status of battery packs and the cost-effectiveness of employing used EV batteries.

Additionally, other studies(Pagliaro and Meneguzzo , Cusenza, Guarino et al. 2019) suggested utilizing used batteries in energy storage systems (ESSs). This economical method would greatly minimize the amount of trash that is harmful to both human health and the environment, which will also reduce the cost of EVs.

This study uses the transport sector of Pakistan as a case study and proposes an economic calculation of different scenarios for sustainable transportation in the region. This study used the Long-range Energy Alternative Planning (LEAP) framework to estimate the social and environmental costs of three scenarios, Efficient Combustion Scenario (ECS), Business as Usual Scenario (BAUS), and Hybrid Vehicle Scenario (HVS). The result shows that by 2040, the ECS and HVS and will be decrease carbon dioxide emissions by 303.7 and 213.3 million metric tons correspondingly linked to BAUS. These savings in stints of social cost will be US$ 10.1 billion in HVS and US$ 7.2 billion in ECS as related to BAUS. By the year 2040, oil demand in the transportation system will also be possible to contain at the 2026 level. It is anticipated that this research would help in determining the optimum course of action for raising the percentage of green fuels in Pakistan's transport sector(Shahid, Ullah et al. 2022).

In fact, (Richa, Babbitt et al. 2017) shown that combining ESSs with end-of-life EV batteries has a benefit that is about 10 times greater than making new ones. Also, there has been a lot of advancement in recent years regarding the battery's useful life. In instance, it is predicted that they now have a 20% reduction in storage capacity after 1500 to 3000 charging cycles. Technology advancements are predicted to enable batteries to achieve 10,000 cycles by 2030 (Few, Schmidt et al. 2018, Hoekstra 2019)

BEVs have the advantage of requiring less maintenance than ICEVs, having no moving parts other than the rotor, and ensuring a longer lifespan than fossil-fuel-powered vehicles (Berckmans, Messagie et al. 2017, Crabtree, Kocs et al. 2017).

According to numerous authors, EVs are anticipated to be more profitable than ICEVs by 2050 (Gambhir, Lawrence et al. 2015) and the market share of ICEV will drop from 99 to 68% as a result of lower operating and maintenance costs (Berckmans, Messagie et al. 2017).

Thus, EVs will ultimately be more advantageous due to an increase in battery useful life and low maintenance costs. (Siragusa, Tumino et al. 2022) compared electric vans with ICEVs for last-mile deliveries in line with this.

This study specifically emphasized many benefits of using EVs, including: 40% lower repair and maintenance costs, 60% lower refueling prices, 35% lower insurance costs, absence of road tolls, and absence of property tax. In the end, EV and ICEV operating expenditures were 35 and 73% of their total cost of ownership (TCO), respectively.

In this situation, it became apparent that using an EV is more cost-effective than using an ICEV after 4.5 years of ownership. In line with this, (Costa, Barbosa et al. 2021) mentioned how the economic advantages rely on the end user's mobility profile.

The authors assumed that the greater the price differential between the two types of vehicles, the greater the travelled distance required to make the EV a beneficial solution from an economic perspective, which would then result in an increase in the payback time. This assumption was made specifically in relation to the acquisition cost of electric and combustion vehicles and the costs of power supply (electricity and fuel costs).

In contrast, (de Mello Bandeira, Goes et al. 2019) demonstrated the economic unviability of an EV when compared to an ICEV by comparing the traditional strategy for postal delivery in the city of Rio de Janeiro with an alternate model that uses an electric LDV (Light Duty Vehicle). The findings revealed that despite the environmental advantages associated with using EVs, the cost of the electrical LDV significantly raises the total delivery cost per route, increasing it by 6.16% in comparison to the conventional system.

Recently, Various Bus Rapid Transit (BRT) projects have recently been launched in Pakistan. The detailed analysis of the cost and capacity of Pakistan's BRT projects showed that their cost could have been minimized. This study estimated the first BRT project in Karachi for latent cost optimization through proper placement of the BRT. One of the key segments of the Green-Line BRT from Surjani to Nagan was calculated, which is currently proposed as an elevated portion. It thoroughly investigated other possible solutions such curb-side, two-way side and median alignments. The studies showed that by implementing a two-way side aligned or curb-side aligned BRT infrastructure, the cost of this segment could have been reduced from the existing USD 75 million to USD 61 million without affecting present capacity. This case study demonstrates the need of carefully evaluating all available options when developing and designing large-scale transportation projects(Khan, Ahmed et al. 2022).

2.6 **Government policies regarding transportation systems based on electric vehicles:**

With increasing global concern regarding climate change and oil consumption, the adoption of BEVs has now become an important step towards an improved transportation system for modern society (Żelazna, Bojar et al. 2020, Galati, Migliore et al. 2022, Guo, Kelly et al. 2022). In fact, the primary goal of European and United States transportation policies is the electrification of transportation. According to the EU's "Fit for 55" programme for 2030, only 20% of all vehicles should be powered only by internal combustion engines by that year (ICEs; i.e., petrol and diesel). This is very ambitious considering that EVs only made up 18% of the automobile industry in (EAFO, 2022).

This type of strategy will probably make it difficult to build an ever-increasing number of EVs and supply electric parts for vehicle production if this idea becomes legislation with the necessity to replace fossil fuel-based vehicles with EVs.

The government incentives offered may also make it possible to accomplish the aforementioned goals. (Ebrie and Kim 2022) asserted that tax incentives and direct subsidies for EV purchases have a substantial impact on EV adoption in light of this.

According to (Allahmoradi, Mirzamohammadi et al. 2022), the main factors influencing consumers' choices are as follows: decreasing the price gap between EV and ICEVs by subsidizing EVs; raising the price of fuel; extending EV travel ranges by upgrading the infrastructure for charging and/or increasing battery capacity; and raising the top speeds of EVs. Therefore, (Thiel, Tsakalidis et al. 2020)found that purchasers chose to acquire an EV if it is economically practical for them. They analyzed EV adoption patterns in Italy.

(Peiseler and Serrenho 2022) made a similar case for the need for improved governmental incentives. The authors specifically suggested categorizing automobiles according to their emissions and taking emissions into account in both subsidy programmes and the system of road taxes. They also recommended looking at end-of-life vehicle directives. In addition to employing policy incentives to reduce the cost difference between EVs and ICEVs, it is essential to take additional policy steps to ease range anxiety by setting up an adequate number of publicly accessible charging stations (Thiel, Tsakalidis et al. 2020).

Similar to this, (Tsakalidis, Julea et al. 2019) suggested that EV adoption is significantly increased by having a sufficient charging infrastructure. In a similar vein, (Rosenberger, Tapia et al. 2022)used the example of commercial EVs to study the city of Hamburg and came to the conclusion that revising the rules related EV charging infrastructure and expanding it would enhance electrification by 35%. The same was supported by ICCT's (2022) investigation for Italy.

Extending public charging infrastructure is essential to moving towards an EV-based transportation system. Also, suitable charging systems must be created. Importantly, (Petrauskiene, Dvarioniene et al. 2020) thought that enhancing charging infrastructure and rigorously regulating the energy sources for EVs to boost the use of renewable energy can have a desirable consequence in the continued development of transportation regulations.

This is supported by (Sommer and Vance 2021) research of the German market, which found that the inadequate territorial coverage of charging infrastructure is the primary obstacle to EV adoption even though Germany greatly surpasses the EU's advised minimum ratio of one charging point to ten EVs. According to some scholars, the adoption of EVs and the growth in the number of charging stations are positively associated.

In fact, (White, Carrel et al. 2022) studied the American metropolises of Los Angeles, Dallas/Fort Worth, and Atlanta and discovered that government incentives to increase the availability of charging infrastructure guarantee customers' unrestricted freedom of movement and are essential to the widespread adoption of EVs.

According to (Newman, Wells et al. 2014), although commercial vehicles have significant problems as a result of having to deliver goods in rural areas, the electrification of transportation has a favorable impact on society overall.

(Napoli, Polimeni et al. 2021) emphasized about the significance of EV adoption in the logistics industry in this context as it represents the most economical step towards carbon reduction. The UK's situation is notable because it was the first to use electric vehicles for delivery services. A law requiring net-zero greenhouse gas emissions by 2050 was approved by the UK parliament.

The UK government has declared a restriction on the sale of new ICEs beginning in 2035 in order to achieve this goal. This is one of the "10 Points for a Green Industrial Revolution" in the UK (Uk 2020).

The government additionally provides high-skilled green workplaces, investments in alternative energy sources, and support for the replacement of conventional commercial transportation with zero-emission alternatives, in addition to grants for the purchase of EVs. Also, it is spending £1.3 billion on charging infrastructure in an effort to make the switch to EVs as easy as possible.

Furthermore, the UK logistics sector is ready to switch to a reliable and environmentally friendly transportation system. Yet, in 2019, the percentage of electric vans sold in the UK was barely 1%. To address the aforementioned problem, (Newman, Wells et al. 2014) proposed new policies for suburban and rural communities as well as more thorough study in the area.

In his analysis of the Australian market, (Allan 2012) raised the same issue for decision-makers and suggested that the nation would not be able to meet the demands of the EV market without an adequate charging infrastructure. This is due to the fact that EVs have an 80–90% lower capacity and a far longer recharge time than their equivalents powered by fossil fuels. Thus, this expert proposed that Australia reconsider its transportation and infrastructure spending.

2.7 Conclusion Analysis for the selection procedure:

The widespread interest in open transportation among city directors and organizers has aroused a lot of academic inquiry. Recently, several tests that disseminated or selected options for transportation utilizing dynamic procedures with multiple criteria, fluffy and mixed applications, and scientific approaches were made available. In these investigations, methods for the transportation decision cycle, such as fluffy numbers, TOPSIS, VIKOR, ELECTRE, scientific organization measure (ANP), and half-breed approaches, were applied. Even though a complex determination measure should consider numerous standards and prerequisites, the model is unable to deliver the desired dynamic.

The literature review amply indicates the importance of electric vehicles as a study topic, both theoretically and practically. The most fascinating and challenging topic, however, may be the choice of electric transportation because of its distinctive features in the context of electric vehicle development.

This study used an annual time series dataset spanning from 1990 to 2020 to examine the role of green energy consumption, eco innovation, and urbanization while expressing the desire of a low-carbon economy and environmental sustainability in the context of Pakistan.

The symmetric, asymmetric, and quantile autoregressive distributed lag models were employed to investigate the short-run and long-run correlations among explained and explanatory variables.

The study's results indicated that under symmetric, asymmetric, and quantile autoregressive distributed lag models, the labor force, urbanization, consumption of green energy, ecological innovation, and GDP per capita are all cointegrated for the long-term association. In addition, efficient eco-innovation and the use of green energy are the best ways to assure environmental sustainability, whereas urbanization, GDP per person, and labor force have a negative impact on the low-carbon economy. By focusing on green energy consumption, ecological innovation, and controlled urbanization as well as the integration of environmentally friendly policies into economic development policies, the authors of the study finding provides a policy framework for the creation of a comprehensive strategy to promote environmental sustainability in Pakistan(Ullah, Abbas et al. 2023).

3 METHODOLOGY

3.1 Research Design:

In this study, the primary research design is based on applied quantitative and qualitative analysis where the researcher will inquire about the usage and consumption of energy in Plugin Electric Vehicles (PEVs) for the Mass Transit (BRT) of Islamabad and Rawalpindi, Public Transportation currently operational in the zone as well as any Private services. The author will conduct both financial and socio-environmental feasibility of using electricity instead to fossil fuel. The financial comparative analysis of using fossil fuel or electricity will be done through quantitative analysis. Whereas the socio-environmental between the two will be calculated through qualitative analysis.

The author wishes to establish workable policies regarding PEVs adaption in the Federal capital Islamabad according to recent policy purposed by Dr. Naveed Arslan of LUMS university on PEVs usage (Ullah 2019). Furthermore, the author will determine the energy consumption patterns of the Electric Buses for the pre-existing Bus Routes of Islamabad and Rawalpindi.

3.2 Data Methodology:

The author, based on the first objective of this study, will adopt the findings of Sustainable Public Transportation Plan proposed by Khizar (2020) where she established Public Bus Transport routes for Islamabad-Rawalpindi. These routes will be used to total the FFV vs EV (Fossil Fuel Vehicles and Electric Vehicles) consumption patterns. Method employed for the recording these routes is based on GeoTime tracing where an object moves in between t and Δt (where t is the stay still point of the route and Δt is the change in the length of the route).

The researcher will employ both primary and secondary data sources. Firstly, the primary data would be collected on the number of pre-existing Bus Routes including the Metro Bus System of Islamabad and Rawalpindi and secondary data from the Khizar (2020) on the routes. The data collected would be of the following factors.

- Road Length and Travel Distance
- Timetable on Bus Usage (Preexisting)
- Bus Stops (Number of stations in a single Bus Route)

Secondly, the second sources would be used to collect data on other factors in the equation of energy consumption model of EVs (Burkhart and Aurich 2015).

Equation 1

$$E_{total} = t * P$$

Where,

- P = Power
- T = Time between two set points

and to calculate power,

Equation 2

$$\mathrm{P} = v * \ \Sigma\ F$$

Where,

- V = Velocity of the Bus∑F = Total Forces acting on or moving the vehicle like acceleration and air resistance and the total force is calculated.

Equation 3

∑F = F rail + F grade + F air + F ace

Where,

- F roll = the force that prevents rolling. It is where the force between the tyres and the roadinteracts.
- F grade = the force connected to grade. This could be negative if the vehicle is travelling downward because gravity will then be helping in speed.
- F air = the resistance of the vehicle against the air.
- F ace = the acceleration force acting on the vehicle.

Secondary data will also be collected on the Terrain (Road Quality and Elevation changes) in the Routes of the Buses, Duration of travel of each Bus (Time between each stops) and the durationof stops (2-minute wait for passengers)(Abousleiman and Rawashdeh 2015).

For equation 1, the author needs to calculate the Time required to travel. The research would use the following equation for that.

Equation 4

$$\text{Time (t)} = \frac{E(t + \Delta t) - E(t)}{D(t + \Delta t) - D(t)} * \alpha * \beta$$

Where,

E = the elevation over the time span (t, Δt)

D = the distance (length of the route) a bus travels in the single time step Δt (One second is used in this study for Δt).

α = the traffic response and increase or decrease in traffic.

β = Go and Stop status of the vehicle (traffic stops).

For the assessment of the socio-environmental comparison between FFV and EV, the author wish to adapt an econometrics model of environment impact of both the types of vehicles.

Equation 5

$$E.I_{i.p} = \Sigma i * \Sigma p \ (fc_{i.p} * C_i)$$

Where, E.I represents environment indictors used to determine the impact of the resource used in alternative transportation modes.

i = the resource used for the vehicle (FF and E).

p = Production, Processing, Transport, Recycling and Disposal of the used resource.

Ci = the input and output flow of the resource.

Fcip = the specific eco indictor mentioned above.

3.3 Data Collection Technique

There are two techniques used for data collection. First, the data collected for routes and timetable of Metro Bus System of Islamabad and Rawalpindi will be collected through primary interrogation like direct interviews and quires with different public authorities like Department ofTransportation Government of Punjab. Apart from this the authors will take the quotations from different companies for the cost analyzing and bus selection through an emails or interview and will suggest the affordable model.

Secondly, the secondary data was collected from online sources like open street map, Google map, Google earth, Google earth catalog and humanitarian data exchange. These types of data collected these online sources includes roads quality, traffic response. Secondary data will also be collectedon Routes of Bus services proposed on current mobility trends.

3.4 Data Analysis Technique

The authors will use QGIS software to establish and organize routes of pre-existing buses following under mass transit and public transportation plan in Islamabad and Rawalpindi.

QGIS and ORS (plug in) tools will be used to create especial data base and QGIS maps of the length and duration of routes measured in kilometers including traffic response and road quality to calculate both Fossil Fuel and electricity consumption based on the equation above.

4 RESULTS AND DISCUSSION:

4.1 Brief about Calculations:

We have to calculate the forces for the individual buses. Equation No 1: ∑F = F rail + F grade + F air + F ace. The F roll essentially represents the rolling resistance force. The force interface between the tyres and the ground is called F grade, and the force is grade related. If the vehicle is moving downward, this could be detrimental because gravity will be assisting in propulsion in this situation. F air is the vehicle's resistance to the air, and F ace is the acceleration force acting on the vehicle. This formula has been used to determine the total of these forces separately for each type of bus.

Table 4.1: Forces for all categories

Forces (N)	For Electric Buses	For Diesel Buses	For Solar Buses
F_{rail}	360	320	63.5
F_{grade}	97,200	86,400	17145
F_{air}	105332.4	105332.4	105332.4
F_{ace}	127.47	125.6	94.08
∑F	**203019.8**	**192177.6**	**122634.9**

In Table 4.2 we have calculated the ∑F that is Total Forces acting on or moving the vehicle like acceleration and air resistance by using the formula for Electric buses, Diesel buses and Solar buses. The total force required to run electric buses is 203019.8 N for diesel buses 192177.6 N and for solar buses 122634.9 N.

Table 4.2: Preexisting Bus Routes of Islamabad and Rawalpindi

Route No.	Distance (km)	Duration (hours)	Routes
1	44.513	0.884	Bhara Kahu to Morga
2	130.716	2.82	G-6 through RWP to I-8
3	24.324	0.5	I-8 to PWD Housing Society
4	44.451	1.063	Islamabad Sectors
5	83.08	1.541	PIEAS to Rawat
6	89.444	1.911	PIEAS to Rawat to Afzal Town
7	17.056	0.332	Pir Sohawa to F-7 Markaz
8	67.885	1.545	QAU to Saddar
9	20.918	0.564	Rawalpindi Medical Line
10	97.661	2.309	Satellite Town to Blue Area

In Table 4.2 we have taken the preexisting routes for Islamabad and Rawalpindi. In column three time is taken in hours but in the coming tables this time is converted into seconds through formula. The data is collected from the following factors.

- Road Length and Travel Distance
- Timetable on Bus Usage (Preexisting)
- Bus Stops (Number of stations in a single Bus Route)

Time, Power, and Energy consumption through given below formulas.

(1) Time (t) $\frac{E(t+=t)-E(t)}{D(t+\Delta t)-D(t)} * \alpha * \beta$

In this formula E represent the elevation over the time span (t, Δt) while D signify the distance (length of the route) a bus travels in the single time step Δt (One second is used in this study for Δt), α shows the traffic response and increase or decrease in traffic and β represent Go and Stop status of the vehicle (traffic stops).

For the assessment of the socio-environmental comparison between FFV and EV, the author wants to adapt an econometrics model of environmental impact of both the types of vehicles.

(2) $P = v \times \sum F$

Where, V is the Velocity of the Bus and ∑F represent the total Forces acting on or moving the vehicle like acceleration and air resistance.

In formula two power is equal to velocity (V) multiply F characterize the total Forces acting on or moving the vehicle like acceleration and air resistance (∑F). Velocity for electric and solar bus is 2.6 but for diesel bus, is 4.7.

Velocity for diesel bus is higher because when a diesel bus running on fuel, 70 percent of its fuel is used, and the remaining 30 percent is going to waste. For fuel efficiency of modern vehicles, they are trying to convert them into half hybrid vehicles so that they can run on 30 percent electricity and energy loss will be 10 percent. All vehicles that are currently running in Pakistan, 70 percent of their fuel is being used and the remaining 30 percent is being wasted.

(3) $E_{Total} = t \times P$

In this formula P shows the Power and T shows time between two set points.

In table 4.3 Time is the same for all buses. While power (P) and total Energy (E) are different for Deasil bus, Electric bus, and Solar bus.

Table 4.3: Energy Consumption of Diesel Bus

No. of Routes	Distance Km	Time (T) minutes	Power (P) watt (w)	Energy (E) kilowatt hour
1	44.513	0.884	903234.72	1092914.0
2	130.716	2.82	903234.72	370.3
3	24.324	0.5	903234.72	1806.4
4	44.451	1.063	903234.72	1083.8
5	83.08	1.541	903234.72	5871.0
6	89.444	1.911	903234.72	541.9
7	17.056	0.332	903234.72	2769.7
8	67.885	1.545	903234.72	6322.6
9	20.918	0.564	903234.72	1806.4
10	97.661	2.309	903234.72	451.6

As mentioned in the beginning, distance and time are the same for all kinds of buses but power and energy are different. So, using the formula which is given in the methodology section, we have found out the power and energy for all types of buses.

4.2 For Electric Bus:

Table 4.4: Energy Consumption of Electric Bus

No of Route	Distance km	Time (T) minute	Power (P) watt (w)	Energy (E) kilowatt hour
1	44.513	0.884	507549.5	614134.8
2	130.716	2.82	507549.5	208.0
3	24.324	0.5	507549.5	1050.0
4	44.451	1.063	507549.5	609.0
5	83.08	1.541	507549.5	32990.7
6	89.444	1.911	507549.5	304.0
7	17.056	0.332	507549.5	1522.6
8	67.885	1.545	507549.5	3552.8
9	20.918	0.564	507549.5	1015.0
10	97.661	2.309	507549.5	279.1

4.3 For Solar Bus:

Table 4.5: Energy Consumption of Solar Bus

No of Route	Distance km	Time (T) minutes	Power (P) watt (w)	Energy (E) kilowatt hour
1	44.513	0.884	306587.2	370970.5
2	130.716	2.82	306587.2	125.7
3	24.324	0.5	306587.2	613.1
4	44.451	1.063	306587.2	369.9

5	83.08	1.541	306587.2	1992.8
6	89.444	1.911	306587.2	183.9
7	17.056	0.332	306587.2	919.7
8	67.885	1.545	306587.2	2146.1
9	20.918	0.564	306587.2	613.1
10	97.661	2.309	306587.2	168.6

In the above tables 4.3, 4.4 and 4.5 total ten routes are taken for Islamabad and Rawalpindi. Time (T) and distance is same because we are doing comparisons among Electric buses, Diesel buses and Solar buses so, distance and time is same for all buses. Power and energy are different for Electric buses, Diesel buses and Solar buses.

4.4 **Analysis**

Table 4.6: Total Energy Consumption of the Buses

Buses Category	Duration (hours)	Average of the bus Energy (E) kilowatt hour
Diesel Bus	13.4	111393.37
Electric Bus	13.4	65566.6
Solar Bus	13.4	37810.34

In this research we are assuming total ten routes and combining these routes the total distance becomes 13.4 hours.

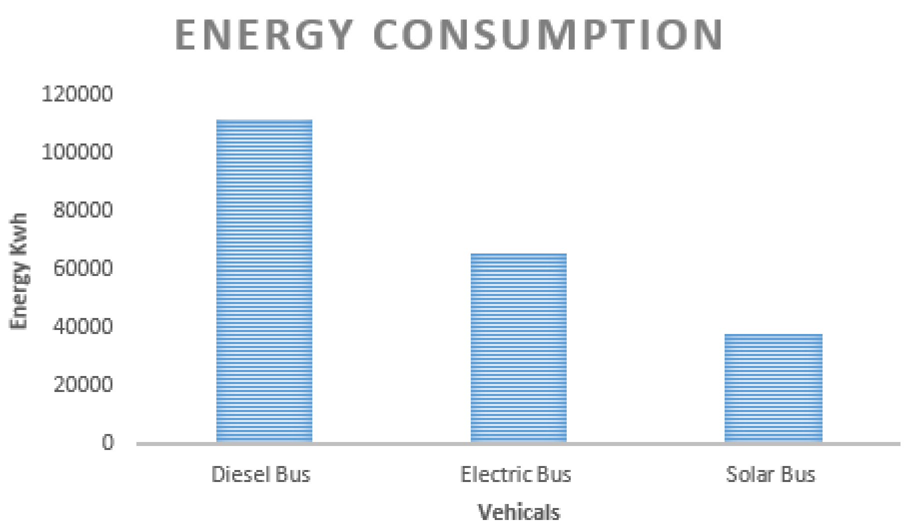

Figure 4.1: Energy Consumption Comparison of all Buses

The above diagram shows that diesel buses consume more energy than electric buses and solar buses.

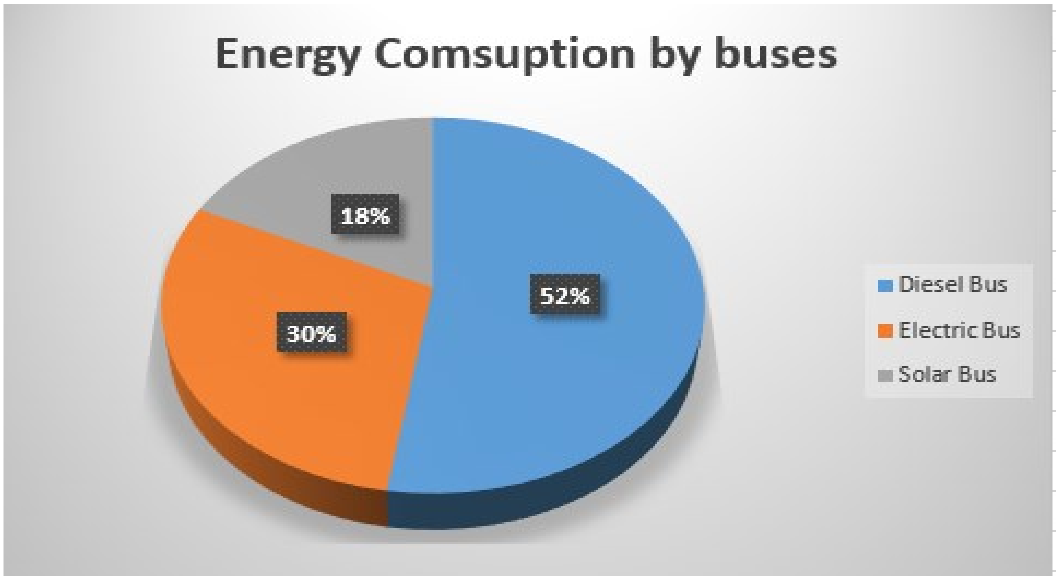

Figure 4.2: Energy Consumption Comparison of all Buses (Pie Chart)

The above diagram shows that diesel bus consumes total 52% energy, electric bus consumes 30% while solar bus consumes only 18% energy. So, we can say that the electric bus and solar bus are quite better than diesel bus.

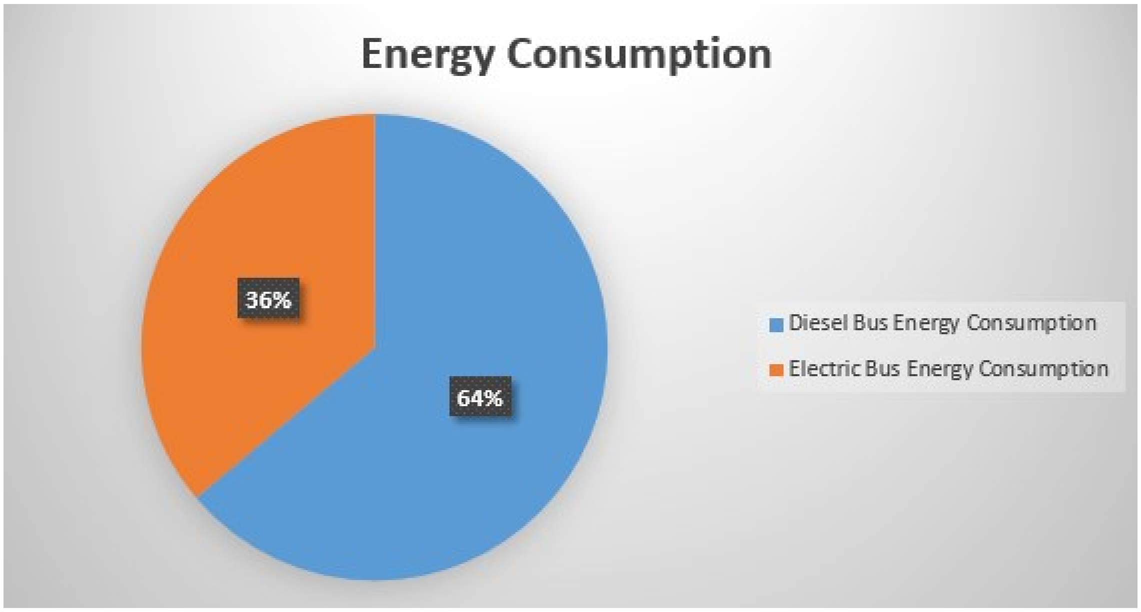

Figure 4.3: Energy Consumption Comparison of diesel and electric buses (Pie Chart)

If we do the comparison between diesel bus and solar bus than the diesel bus consumes 64% energy and electric bus consumes 36% of the total energy.

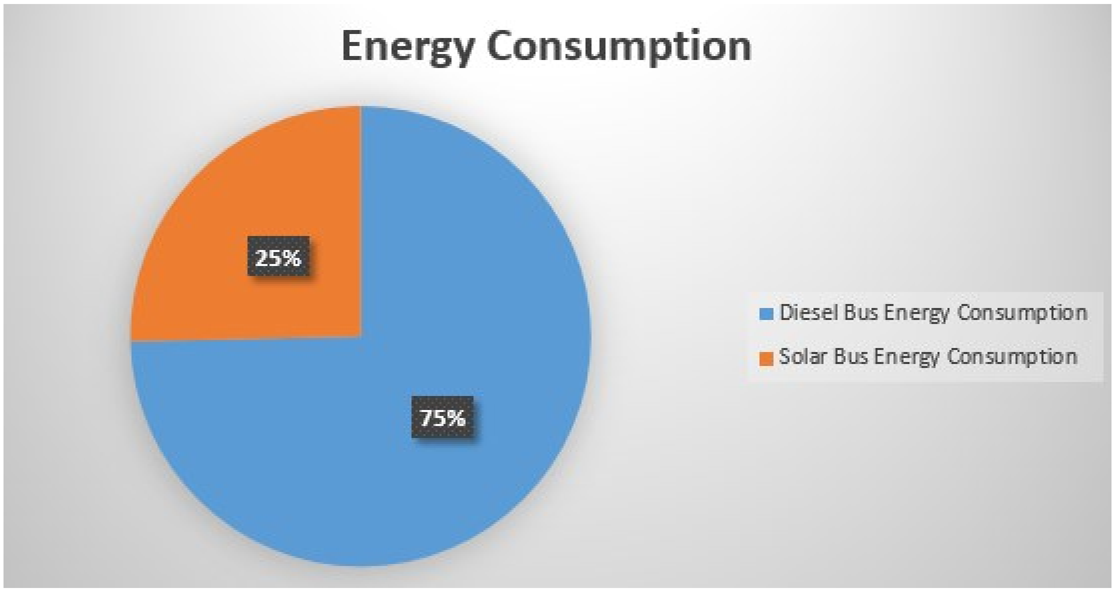

Figure 4.4*: Energy Consumption Comparison of all Buses (Pie Chart)*

Above diagram shows that diesel bus consumes 75% energy and solar bus consume only 25% energy.

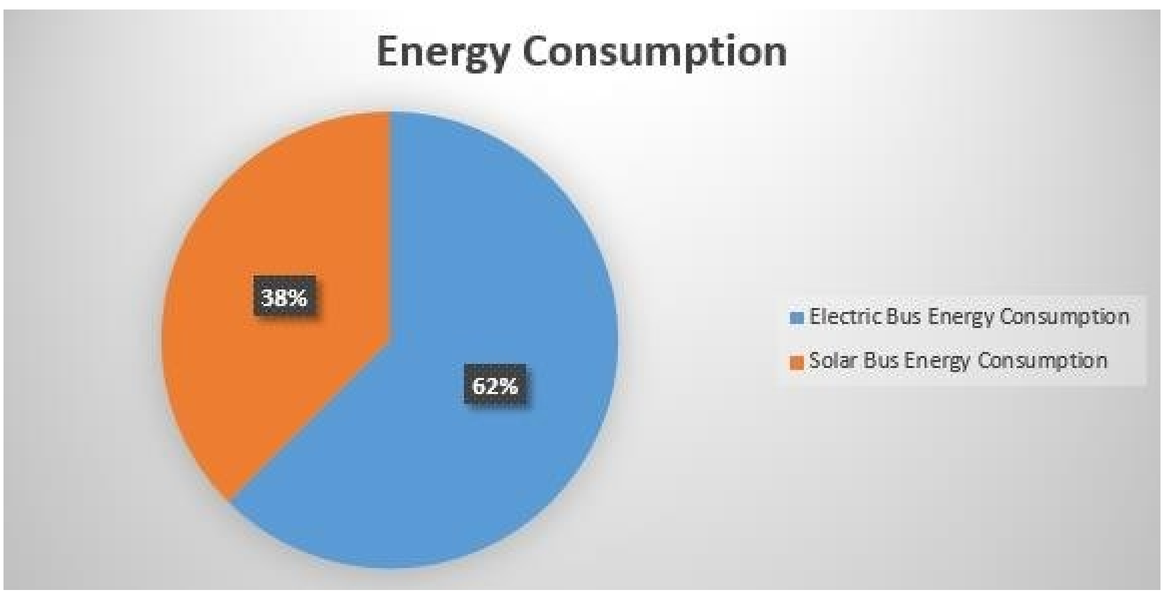

Figure 4.5: Energy Consumption Comparison of all Buses (Pie Chart)

Above diagram shows the comparison between electric bus and solar bus. So solar bus consumes 38%energy and electric bus consume 62% energy.

Pakistan's annual import of oil and gas accounts for about 80%. “If all 240,000 buses in Pakistan were changed into electric ones, it would save a lot of fuel, and the dependence on imports will be largely reduced. 40-50% of traffic emissions pollution can be lessened,” said Liu Xueliang, General Manager of Asia Pacific Auto Sales Division, BYD.

Figure 4.6: Energy Comparison of diesel and electric bus

A	B	C
Diesel Bus		
	Quantity	Units
Energy in one Liter of Diesel	10	Kwh
Diesel Bus Consumption per 100 Km	40	Liters
Energy in 40 Liter of Diesel	400	Kwh
Evs		
Energy Consumption Per Km	1.3	Kwh
Energy Consumption in 100 Km	130	Kwh
Total Energy saved	270	Kwh

4.5 Financial Analysis

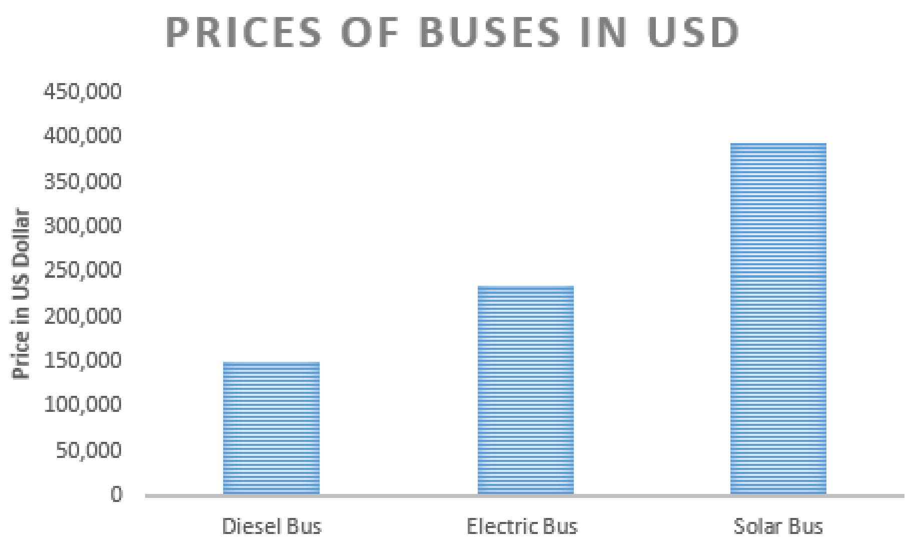

Figure 4.7: Financial Comparison of all buses

For the introducing of any new project its financial cost matters. The recent price of diesel bus is 150,000US$, electric bus is 235,000 US$ and for the solar bus is 395,000US$. In a comparison among electric buses, diesel buses and solar buses the result shows that electric buses are still more expensive that fossil fueled buses, electric buses can provide cost saving over the long run. Prices for diesel, electric and solar buses have been acquired from M/s Hino Motors Global, M/s Zhengzhou Yutong China and M/s.

4.6 Discussion:

Table 4.7: Total Distance in miles for all routes under consideration

Route No.	Distance (km)	Duration (hours)	Routes	Total Distance Both sides (km)	Distance (Miles)	Charging Station Required
1	44.513	0.884	Bhara Kahu to Morga	89.026	55	2
2	130.716	2.82	G-6 through RWP to I-8	261.432	162	5
3	24.324	0.5	I-8 to PWD Housing Society	48.648	30	1
4	44.451	1.063	Islamabad Sectors	88.902	55	2
5	83.08	1.541	PIEAS to Rawat	166.16	103	3
6	89.444	1.911	PIEAS to Rawat to Afzal	178.888	111	3
7	17.056	0.332	Pir Sohawa to F-7 Markaz	34.112	21	1
8	67.885	1.545	QAU to Saddar	135.77	84	3
9	20.918	0.564	Rawalpindi Medical Line	41.836	26	1
10	97.661	2.309	Satellite Town to Blue Area	195.322	121	4
	620.048	**13.469**		**1240.096**	**768**	**25**

In this research author takes total ten routes of Islamabad city for all buses as mentioned in below table. It is quite evident from the estimations that bus will cover **768 miles** (round trips) as a whole for all these ten routes in **13.5 hours**. Total number of charging station required for all routes are **25** as a whole. As rule of thumb one charging station is required for after each 40 miles, because batteries powered vehicles can cover 40 miles with initial full charge.

Table 4.8 Cost of Charging Station

Cost of Charging Station	
Charger	$20,000
Installation	$1,000
New Connection	$2,500
Misc. @ 10%	$2,350
Total Cost (USD) / Charging Station	$25,850
Total Cost (PKR) / Charging station	723800
No. Charging Station Required	25
Total Cost of all charging stations (billion PKR)	0.18

The installation cost included the labor cost, material cost, and other such parameters; the new connection cost was the cost of the regulator, and in the case of the transformer, there was a minimum cost both for the regulator and transformer. The operational and maintenance cost was taken as the 10% annual cost. The electricity and taxes costs were obtained from the provider, while we had to consider the rupee devaluation for investment and some miscellaneous charges, as this is the new technology, and there will inevitably be some unknown annual charges.

Cost and benefit analysis for all three buses (diesel, electric and solar) has been mentioned in the following table.

Following equations were used in the analysis:

1. Average Cost (Rs) = Average energy consumption (kWh) * Cost of Generation (Rs/kWh)
2. Depreciation cost per route= Duration of all routes * Average Cost
3. Adjusted Cost (PKR) = Average Cost + Depreciation cost per route

4. Net Saving (Billion PKR) = HSD Import bill reduction + Adjustment of Charging Station

For the estimation of savings of EVs and solar buses, adjusted cost has been determined by including depreciation cost, price of single unit of energy and amount of total energy consumed by each vehicle. During the analysis, considerable savings have been recorded from both electric and solar bus as 41% and 65% respectively. Use of electric bus and solar bus can save up to 220.62 and 353 billion PKRs of Total HSD Import bill. Moreover, Net savings by adding charging station adjustment has been recorded as 220.81 and 353.18 billion PKR for electric and solar bus respectively.

Table 4.9: Net saving overview of Electric and Solar Bus in comparison with diesel bus

Sr. #	Description	Diesel Bus	Electric Bus	Solar Bus
1	Duration (Hrs.)	13.4	13.4	13.4
2	Prices (USD)	150,000	235,000	395,000
3	Prices (PKR) (1 USD = 280 PKR)	42,000,000	65,800,000	110,600,000
4	Average Life of Bus (Km)	250,000	250,000	250,000
5	Depreciation	168	263.2	442.4
6	Average Bus Energy Consumption (kWh)	111393.37	65566.6	37810.34
7	Cost of Generation (Rs/ kWh) *	6.2654	6.2654	6.2654
8	Average Cost (PKR)	697924.02	410800.98	236896.90
9	Depreciation per route	2251.2	3526.88	5928.16
10	Adjusted Cost (PKR)	700175.22	414327.86	242825.06
11	Net Saving	-	40.8%	65.3%
12	Import Bill of Diesel (Billion PKR)**	540.42	319.80	187.42
13	Saving of Import Bill (Billion PKR)	-	220.63	353.00
14	Adjustment for charging station	-	0.18	0.18
15	Net Saving (Billion PKR)	-	220.81	353.18

Total import bill for all petroleum products for the year 2022 is $4,6405,690,00, while 42% of this amount ($1,930,087,598) is being consumed for HSD only. Which needs to address on priority basis. Introduction of EVs and solar buses can definitely reduce import bills as reflected in aforementioned analysis. Electric and solar buses requires less fossil fuel power energy as compare to diesel buses, while having same passengers' capacity. Which reflects benefits of these batteries powered vehicles over diesel buses.

Table 4.10: Pakistan Energy Yearbook 2021

Fuel Mix 2020-21		
Aviation Fuel	185,872	1%
Motor Spirit	8,889,188	49%
HOBC	172,865	1%
Kerosene	0	0%
HSD	7,481,533	42%
LDO	0	0%
Furnace OIL	175	0%
Electricity	0	0%
Natural Gas	1,258,447	7%
Total Tons of Oil Equivalent	**17,988,080**	

4.7 Environmental Impacts of different transport vehicles:

The 200,000 km assumed for vehicle and battery lifespan is in line with the average lifetime estimates given by the automobile industry. Consumption phase is primarily responsible for the GWP impact, either directly through fuel combustion or indirectly through the production of electricity.

Using the base case assumption of a 200,000 km vehicle lifetime, EVs are found to lower GWP by 20% to 24% compared to gasoline FFVs and by 10% to 14% relative to diesel FFVs when fueled by typical European electricity.

We predict that LiNCM EVs offer a reduction in GHG emissions of 12% when compared to gasoline FFVs and achieve break-even with diesel FFVs when fueled by electricity generated from natural gas. Compared to diesel and gasoline FFVs, coal electricity-powered EVs are predicted to result in a 17%–27% increase in global warming potential (GWP).

In comparison to FFVs, the production of an EV accounts for roughly half of its life cycle GWP. We calculate that the GWP from the manufacture of EVs will be between 87 and 95 grams of carbon dioxide equivalent per kilometer (g CO2-eq/km), or about twice as much as the 43 g CO2-eq/km attributed to the production of FFVs.

The GWP of the EV production phase is mostly made up of the manufacturing of batteries, which accounts for 35% to 41% of the total. 16% to 18% of the embedded GWP of EVs comes from other powertrain parts, particularly inverters and the passive battery cooling system with its high aluminum content.

Due to the higher energy density of their batteries, LiNCM EVs have a marginally lower GWP impact than LiFePO4 EVs when life expectancies are held constant. The LiNCM and LiFePO4 cars have life cycle GWP intensities of 197 and 206 g CO2-eq/km, respectively, with the European electricity mix.

Assuming a vehicle lifetime of 200,000 km exaggerates the GWP benefits of EVs to 27% to 29% relative to gasoline vehicles or 17% to 20% relative to diesel vehicles because production-related impacts are distributed over the longer lifetime. This is because production impacts are more significant for EVs than conventional vehicles. The benefit of EVs compared to gasoline vehicles is reduced to 9% to 14% under the assumption of 100,000 km, and the environmental effects are same to those of a diesel vehicle.

The impact of both the vehicle and the electricity generating process, as well as important elements like energy consumption, battery lives, and vehicle lifetimes, all play a significant role in how environmentally friendly electric vehicles operate. The GWP impact of the diesel FFV would be smaller, for instance, if the calculation was done with a lifetime of 200,000 km for the FFV and a battery replacement assumption during the lifetime of the EV.

EVs are a significant technological advance with significant potential environmental benefits, but they cannot be used everywhere or under all circumstances. Our findings unequivocally show that encouraging EV use in regions where electricity is largely generated by the burning of lignite, coal, or even heavy oil is ineffective. Such electrical mixtures may, at best, result in local emission reductions.

Hence, EVs move emissions off of the road rather than lowering them globally. By using power generated from natural gas, EVs only accomplish a small number of benefits. Increased fuel economy or switching from gasoline to diesel FFVs without considerable issue-shifting could potentially result in a more significant reduction in GWP in the absence of foreseen improvements to power blends (with the exception of smog).

In comparison, the use of EVs in conjunction with clean energy sources could enable significant reductions in the environmental effects of numerous modes of transportation, particularly with regard to climate change, air quality, and the preservation of fossil fuels. So, the numerous benefits of EVs should be a driving force for improving regional electricity mixes, but their promotion should not come before a commitment to grid upgrading.

The benefits across time should be taken into account while considering alternative vehicle technology. While EVs might only provide marginal advantages or even disadvantages under a first-generation grid, their growth and market penetration should be assessed along with plausible long-term scenarios for grid expansion.

EVs appear to have a larger potential to harm humans, freshwater ecosystems, eutrophicate freshwater, and deplete metals. Nonetheless, there is a significant role for uncertainty and risk assessment in this trade-off.

As was previously mentioned, there are considerable uncertainty around both release inventories and characterization parameters in relation to these impacts. In order to effectively promote EVs through policy instruments, it may be necessary to achieve obvious reductions in emissions with known impact potentials, such as GWP and FDP, at the expense of uncertain increases in emissions that may have unknown effects, such as FETP.

A boost of EVs should be combined with stronger life cycle management and life cycle auditing in light of this trade-off. Effective recycling systems and extended EV lives would be a reasonable first reaction, given that the possible problem shifts are mostly caused by the material requirements of EV manufacture.

It is necessary to develop a comprehensive material flow strategy that takes into account component recyclability, alternative materials, and secondary sources.

For policymakers and stakeholders, the change in emissions that EVs are expected to bring about—the elimination of tailpipe emissions at the expense of rising emissions throughout the production chains of cars and electricity—brings new opportunities and concerns.

On the one hand, EVs would consolidate emissions at a few point sources (such as mines, power stations, etc.) as opposed to millions of mobility sources, making it conceptually simpler to monitor and improve societies' transportation networks (McKinsey & Company, 2009).

On the other hand, we face difficulties as a community due to the indirect nature of these emissions, which are embedded in internationally traded commodities like copper, nickel, and energy. It asks if we take life cycle thinking seriously and how much control and monitoring, we, as consumers and policymakers, think should be exercised over production chains.

4.8 Environmental Impacts of Diesel Buses:

Diesel is a fossil fuel, which is extracted from crude oil in the refinery. Diesel is one of the primary sources for energy in Pakistan. Many sectors like power, oil and gas, cement, fertilizers, and manufacturing depend upon this fuel. Diesel’s flash point is considerably low as 50° C as compared to its competitor furnace oil(Yusof, Abas et al. 2021). That’s why diesel is used mostly in internal combustion engines (IC engines used in transport industry widely). When we look upon environmental impacts of fossil fuel-based engines, following consideration will come in the mind.

Diesel is a hydrocarbon-based fuel. Hydrocarbons means hydrogen and carbon molecules are available in this fuel. Combustion of hydrocarbons contributes mainly towards air pollution due to production of primary and secondary pollutants during combustion(Lloyd and Cackette 2001).

List of primary pollutants are mentioned below.

- Carbon monoxide (CO)
- Oxides of Sulfur (SO_X)
- Oxides of nitrogen (NO_X)
- Particles (Soot or Ash)

Interaction of primary pollutants with air or water leads towards formation of secondary pollutants

List of secondary pollutants are as mentioned below.

- Acid Rain
- Smog

Short briefs about all these pollutants are as following.

Carbon Monoxide (CO) is a generated from incomplete combustion of fuel. Hazard of air pollution due to carbon monoxide mainly comes from automobiles and transportation vehicles. Headache, nausea, unconsciousness, or death during extreme conditions are possible consequence during working in area with highly concentrated carbon monoxide or having long exposure in carbon monoxide rich environment(Gabriel, Martin et al. 2021).

Sulfur is also present in fossil fuels and during combustion this sulfur can encounters oxygen. Sulfur dioxide ($SO2$) and sulfur trioxide ($SO3$) are the main products of this interaction.

Sulfur trioxide ($SO3$) can cause problems in respiratory tract. As per study, one volume concentration of ($SO3$) in a million volumes of air can leads towards coughing and choking. Sulfur trioxide ($SO3$) in combination with water makes sulfuric acid ($H2SO4$), which is harmful for metal objects due to its corroding nature.

Nitrogen oxides (NOx) mainly came from nitrogen present in fuel and air and already available oxygen in the air. Nitric oxide (NO) is one of the possible outcomes. Some nitric oxide (NO) is produced during interaction of nitrogen atom and fuel during oxidation of fuel and remaining nitric oxide (NO) is produced during high temperature combustion processes (Jurkovič, Kalina et al. 2020)s. Further interaction of nitric oxide with oxygen results in formation of nitrogen dioxide ($NO2$), which is highly noxious gas for lungs.

Particulate matter emissions (soot and fly ash) mainly disturb lungs, eyes and skin. Constant penetration and exposure of these fine particles into the lungs of humans can decrease the air capacity of the lungs, which will cause breathing and respiratory problems. Chronic asthma and emphysema are also severe outcomes of these PMs Emissions.

Acid rains comes originates from combination of (SOX) or (NOX) with water. Main products from these relationships are sulfuric acid and nitric acid. Oxides of Sulfur (SOX) are main contributors of acid rain. Acid rain can cause water pollution, which is harmful for aquatic living beings. Apart from this, acid rains can decrease pH the soil which can harm the crops and forests(Potkány, Hlatká et al. 2018).

Smog is one of major problem in our big cities of Pakistan like Lahore and Karachi. Such environmental degradations can lead towards respiratory problems, skin, and eyes irritation. Major problem while mitigation plans is that these particles are too much fine and smaller in size. Normal protective masks are not sufficient and adequate against these particles.

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4.9 Environmental Impacts of Electric Vehicle:

4.9.1 No Emissions:

Electric vehicles do not produce zero any "tailpipe emissions". Tailpipe emissions are basically the emissions that came out from exhaust of vehicles during combustion of fuel. Carbon dioxide (CO_2), nitrogen oxides (NO_X), hydrocarbons (HC), sulfur oxides (SO_X), Particulate matter (PM_{10}) are the major examples of tailpipe emissions.

Electric vehicles do not have any internal combustion engine likewise in diesel bus. Electric vehicles do not use any fossil fuel. So, hazard of tailpipe emission is being neglected completely by electric vehicles.

4.9.2 Reduction in air Pollution and noise pollution:

Electric vehicles do not contribute to air pollution of eco-system. Air quality is also being improved due to use of EVs instead of diesel vehicles. Replacing the traditional diesel buses with EVs will also reduce noise pollution in the environment as well.

Improved quality of air due to reduced noise and emissions level can improve human's behavior as well. Nickel is obtained after horizontal surface mining, which leads towards extensive environmental degradations like deforestation and scrapping out the top layer of soil. Such degradation of natural resources should remain under consideration during electrification of transport system.

Extraction of lithium is also a lengthy and difficult process. Lithium extraction can take up to 12 to 18 months. During this process, huge amount of water like 500,000 gallons will be required for one ton of lithium. So, this process also can lead towards water and soil contamination.

Moreover, other elements (cobalt and copper) used in batteries also do have similar types of issues. Batteries can also impact environment in case of poor disposal. Poor disposal techniques can contaminate the water and soil.

4.9.3 Fossil fuel-based production of electric cars:

EVs don't use fossil fuels during running on the roads but their production and supply chain is dependent upon such fuels. Manufacturing of EVs is still not powered or energized from green energy sources like biogas, solar or wind. So, assembling of these vehicles do have carbon and greenhouse gas traces on the environment.

4.9.4 Fossil fuel-based sources for charging of EVs:

EVs are not directly depended upon fossil fuels as they don't have any internal combustion engine. But EVs still depends upon these types of fuels when it comes to the charging of the EVs. Batteries need charging during day-to-day trips. Charging of these batteries is being done through normal AC supply obtained from national gird.

The electricity needed for charging is not usually come from renewable energy sources. We don't know the exact source of the electricity from where EV is going to be charged. Because source of electricity could be thermal, hydro or any other renewable energy source like solar or wind. If we look upon electricity generation mix of Pakistan, 58% of generation is depended upon thermal for the FY (2020-21) as per NTDC Power System Statistics 47th Edition December 2022. This data depicts that charging of these vehicles will mainly contribute form fossil fuels.

EVs usually used lithium-ion batteries. These batteries do have serviceability over 10 to 15 years. These batteries can be recycled. As per new technologies available now a days, we can recover up to 90% of battery components. During recycling process, delicate care should be taken during handling of battery cell electrolyte. This electrolyte can be exposed to human and surroundings which can contaminate the water and soil. So, during recycling, hazard of environmental degradation is always there.

Electric vehicles are being supported by governments and automakers all over the world as a significant technology to reduce oil consumption and combat climate change. While most experts concur, that plug-in cars are a more environmentally friendly option than conventional cars, their construction and charging methods can still have an impact on the environment.

4.9.5 Production of Batteries:

Main or primary source of energy in case of EVs is batteries. Lithium-ion batteries are used mostly in EVs. These batteries have a low self-discharge rate, more charge cycles, high energy density, low maintenance requirements, and are lightweight and small(Yusof, Abas et al. 2021) According to an estimate,calculation for CO_2 emissions was made as mentioned below.

Amount of CO_2 released for 1kilowatt-hour (kWh) = 150 kg

Battery capacity required for decent range(Yusof, Abas et al. 2021) (like 300 miles)

between charges = 60 kWhTotal amount of CO_2 released for 60 kilowatt-hour

(kWh) = 9000 kg

4.9.6 Charging issues:

Electric motors are almost always far greener than conventional cars if you assume they get their energy from the typical American grid, which often consists of a mix of fossil fuel and renewable energy plants. Because of their batteries, electric cars produce more emissions during production, but their electric motors are still greener than traditional internal combustion engines, which burn fossil fuels. However, that is just an average.

4.9.7 Battery manufacturing:

The lithium-ion cells that power most electric motors rely, like many other batteries, on raw minerals like cobalt, lithium, and rare earth elements that have been linked to serious environmental and human rights concerns. Problems with cobalt have been particularly severe. Cobalt mining produces hazardous tailings and slags that could leak into the environment, and studies have shown that nearby communities are very susceptible to cobalt and other metals, especially among children. Smelting, a process used to separate the metals from their ores, is also required. Smelting has the potential to release Sulphur oxide and other hazardous substances that are extremely detrimental to the environment.

4.9.8 Easy Recycling:

According to experts, old batteries contain valuable metals and other materials that can be salvaged and used again. Battery recycling can use a lot of water or discharge toxins into the air, depending on the procedure utilized. Lithium battery recycling rates are now quite low, but they will undoubtedly rise with time and innovation. Finding new uses for used electric vehicle batteries in storage and other areas is one of the encouraging strategies that have been suggested. Lowering the range of mileage by shortening the battery's life.

4.9.9 Quicker Payback:

Based on an average yearly driving distance of roughly 7,800 km for cars in the UK, an electric car will produce 30% less carbon than a conventional car over the course of its roughly 12-year lifespan. It implies that your payback would come quicker the more you drive.

In my perspective, driving a petrol or diesel car can never offset the emissions that were started during the manufacture process.

4.9.10 EVs have no direct tailpipe emissions:

During operation, traditional cars burn fossil fuels, which generates CO2 along with other pollutants including nitrogen oxides that cause a variety of health issues. In comparison, an electric car causes zero direct tailpipe emissions.

4.9.11 EVs will keep getting greener with the electricity grid:

In more than 90% of the world's population, recharging an EV produces fewer carbon emissions than running it on gasoline or diesel. EVs are significantly greener in nations where a big portion of the electricity grid is powered by low-carbon and renewable energy sources. For instance, they produce 70% less carbon during their lifetime than a standard car in France and Sweden.

4.9.12 EV batteries have an environmental impact but are getting greener:

Batteries used in EVs usually made up of metals like nickel, lithium, cobalt, and copper. Extraction of these metal is a big environmental challenge. Battery producers are currently renovating batteries that have need of fewer resources, but there is no disagreeing that they do incorporate an ethical cost just like other goods such as electronics and clothing.

4.9.13 Almost all an EV can be recycled including the battery:

When a battery loses 70% of its capacity, many battery manufacturers advise replacing it. Because they still have a reasonable amount of life in them, manufacturers may convert them into household batteries for storing solar-generated electricity. EV manufacturers taking charge of recycling or reusing batteries from their own models. Nissan, for instance, already powers automated vehicles in their industrial unit using their own approach.

4.10 Environmental Impacts of Solar Buses:

Solar buses are more eco-friendly as compared to diesel or electric vehicles. Because primary source of solar powered bus is not depended upon any type of fossil fuel. Solar buses and electric buses both have advantage of zero emission over diesel bus during running or operation(Shahina, Ebenezer et al. 2021).

Solar buses and electric vehicles do have many similarities like both runs with the batteries. Solar buses and electric buses share some environmental impacts in common due to these similarities. Common environmental impacts will be as following.

- CO_2 Emission during manufacturing of batteries.
- Degradation of natural resources during mining and extraction of rare metals for batteries.
- Use of hydrocarbon or fossil fuel during production of the bus.
- Use of non-renewable energy sources for charging of batteries.
- Handling of hazardous components of batteries during recycling process.

Impacts are due to batteries. Solar buses do have other environmental impacts mainly due to solar panels. Which are listed as mentioned below.

4.10.1 Solar panels manufacturing:

Solar panel is made up of semiconductor material. Semiconductors such as silicon, germanium, and gallium arsenide are used in formation of solar cells(Collins, Powell et al. 2015). Huge amount of energy is being consumed in the process of mining of raw material, manufacturing, and transportation to obtain useable solar module.

During the formation of solar cell, quartz or crystals of raw materials must go through extensive processing and cleaning(Xu, Li et al. 2018). During manufacturing stages, high power consuming heaters are used for heating of quartz. In short, all these processes do need a lot of energy (kWh) which mostly comes from non-renewable energy sources. Use of these non-renewable energy sources will surely impact environment.

4.10.2 Chemicals:

Transformation from raw semiconductor material to a useable solar panel requires an extensive process as mentioned earlier.

During this process, hazardous materials like hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride and acetone are used for cleaning of semiconductor surface. Moreover, toxic chemicals like hydrofluoric acid and sodium hydroxides are also used in the processing stages.

Exposure of these chemicals to humans, water or soil can be harmful and may leads towards degradation of natural resources. Proper disposal techniques should be adopted for management of toxic waste materials hydrofluoric acid and sodium hydroxides are also used in the processing stages.

4.10.3 Solar Waste:

Solar cell technology is quite new in this world, so recycling of solar panel is not being explored very well. Major concern during recycling of solar cells is presence of cadmium and lead in solar cells. Mostly old solar cells are disposed in large landfills(Xu, Li et al. 2018). These toxic elements present in the waste can contaminate soil and water severely.

5 CONCLUSION

Developed nations like the USA, Europe, and others are constantly concentrating on adopting environmentally friendly practices which generate fewer CO2 emissions. One sustainable move is the recent development of electric automobiles. These environmentally conscious regimes should be implemented in South Asian developing countries like Pakistan, Bangladesh, and India. Although the introduction of EVs alone is not the only or entirely solution to attaining a clean and green environment in the nation, taking these actions will help us move closer to an environment with less emissions.

Solar and electric buses are superior to diesel bus while considering overall environmental footprint and impacts. As both solar and electric buses have almost zero emission technology during operation. At present moment or initially, cost-feasibility is positive for diesel bus due to low prices of vehicle in comparison with solar or electric bus and cost-feasibility is negative for electric and solar bus due huge capital expenditure (CAPEX) requirement in the beginning.

In a long run, social feasibility will be positive for electric and solar bus. As human being's attitudes towards environment friendly appliances, equipment and machines are quite optimistic. Behaviors of humans towards energy efficient and environmentally friendly solutions are increasing day by day as shown in upcoming few examples such as, preferring wind or solar energy sources over thermal, replacing old conventional lights with LED. These positive behaviors depict that people will move or prefer electric or solar bus over the diesel bus. Therefore, in the future, social feasibility of diesel bus will be negative.

The detailed analysis and study of both fossil fuel and electric vehicles differentiate the use of both vehicles. The electric vehicles are expensive but their prices are coming down. With new Chinese automotive brands, the prices have become equal to or less than fossil fuel vehicles. Electric vehicles also have less maintenance cost, low fuel cost depends on the source of electricity production, and completely environment friendly, and also have a more safety factor.

Although fossil fuel vehicles are cheap but have a high maintenance cost, more fuel cost and burning of fuel leaves behind the dangerous carbon, Sulfur, and fine particulate matter which are destroying the environment, endangers the human lives, and economy of Pakistan.

It is concluded from this paper that using the electric car in Pakistan can be very useful, cost-saving, environment saving, fuel-saving, and life-saving as well. The increasing population and increasing number of cars on roads are creating serious problems for the nation. As the world is moving towards renewable sources of energy so, it is the responsibility of our government to invest in using the new technology resources to save the lives and environment of Pakistan. In the light of the current automotive market, new electric car manufacturing is encouraged and a tax-free import of electric vehicles is allowed.

6 RECOMMENDATIONS

- Driving the EVs from renewable energy sources will significantly enrich system efficiency the in general.
- Pakistan must implement a successful and environmentally sustainable fuel substitution strategy during economic downturns. Environmentally friendly manufacturing, transportation, and supply production methods should be used to encourage increased growth and sustainable mobility.
- Rethinking physical infrastructure is required, as is the development of green transportation, as well as public education about the usage of and financial investment in green transportation options through tax breaks, subsidies, and incentives.
- Develop local innovation and capacity-building initiatives that will enable local investors to gain from the inflow of capital and cutting-edge technology. The expansion of local markets will be facilitated by this in turn.

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