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The Role of Electric Vehicles in Greening the Environment: Prospects and Challenges

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1 ABSTRACT

Electric cars, also known as Electric vehicles (EVs), possess a smaller ecological footprint compared to traditional internal combustion engine vehicles (ICEVs). While certain aspects of their production may have comparable, reduced, or different environmental impacts, they have the advantage of emitting minimal to no tailpipe emissions. Furthermore, they help reduce reliance on petroleum, decrease greenhouse gas emissions, and mitigate the health effects caused by air and environmental pollution. In recent years, there has been a noticeable research focus on incorporating EVs into smart cities, as they offer a means to reduce urban carbon dioxide (CO2) emissions. Consequently, a limited number of studies have sought to enhance the widespread integration of EVs in order to promote environmental sustainability and contribute to the advancement of the built environment. Consequently this study aims to explore existing literature pertaining to the impact of electric vehicles in promoting a sustainable urban transportation system and fostering an environmentally friendly ecosystem. To accomplish this, the study will employ the Prisma methodology, which involves extracting relevant information from peer-reviewed journals and conference papers. The outcomes of this research endeavor will yield valuable policy implications, aiding policymakers and decision-makers in their efforts to combat climate change and enhance the efficiency of the electric vehicle market.

Keywords: Electric Vehicles, Transport Planning, Smart Cities, Sustainability, Mobility

2 INTRODUCTION

Transportation stands as a pivotal pillar within modern civilization, serving as both a catalyst for economic progress and a generator of employment opportunities (Krishna, 2021). Yet, despite its undeniable significance and the advantages it brings, the observations of Ritchie (2020) underline an alarming reality: the transportation sector emerges as one of the largest and swiftest contributors to carbon dioxide emissions, accounting for a substantial 16.2 percent of the total global CO2 emissions in 2020. This disconcerting trend exacts a toll on human well-being and the environment, as highlighted by Degirmenci and Breitner (2017).

In response to this pressing challenge, Sendek-Matysiak (2019) emphasizes the necessity of addressing air pollution concerns and reducing the overreliance on crude oil for road transportation. Achieving this transformation necessitates the adoption of innovative mobility concepts aligned with principles of sustainable socioeconomic advancement. On an international scale, countries grapple with the imperative to curtail carbon emissions originating from the transportation sector. Alternative energy sources have emerged as promising candidates to supplant fossil fuels, which currently power nearly 92 percent of transportation fleets/vehicles (Khalili et al., 2019).

Within this landscape, electric vehicles (EVs) emerge as a beacon of promise, providing nations the opportunity to shift away from fossil fuel-dependent vehicles towards more environmentally friendly energy alternatives like electricity. By doing so, they effectively address the adverse consequences of climate change that grip the global stage. Sun et al. (2023) underscore the predominant focus on limiting climate change to below 2°C, spurring nations to enact transformative measures. To significantly reduce greenhouse gas emissions, including CO2, a widescale embrace of low-carbon technologies across all sectors becomes paramount (Lamb et al., 2021). While progress strides forward in certain sectors such as electricity, the transportation domain confronts formidable hurdles (Xu et al., 2021). Research by Hao et al. (2016) accentuates road vehicles as the primary emissions source, projecting a doubling of the passenger vehicle fleet by 2050. As all energy sectors grapple with the demand for decarbonization, addressing emissions in transportation emerges as particularly pivotal, given its substantial contribution to greenhouse gas emissions. Consequently, adopting alternative modes of transport like electric vehicles, which do not rely on fossil fuels, becomes a compelling imperative.

An electric vehicle (EV) is characterized by its dependence on one or multiple electric motors to propel it, drawing power from stored electrical energy within batteries or alternative storage systems (Rudatyo & Tresya, 2021). With the potential to address mounting environmental, economic, and energy challenges within transportation—ranging from air quality to climate change and urban expansion (Haddadian et al., 2015)—electric vehicles stand out for their minimized emission of greenhouse gases and pollutants in comparison to traditional gasoline or diesel vehicles (Ehrenberger et al., 2019). Moreover, the integration of electric vehicles holds the potential to bridge the divide between the energy and transportation sectors. This integration generates a wealth of data within smart cities, ushering in fresh prospects and business models for forward-looking enterprises. Thus, companies embracing EVs not only enhance their competitive edge but also fortify their strategic standing. The crux of our study revolves around dissecting the role of electric vehicles in sustainable planning, while simultaneously pinpointing the barriers obstructing their triumphant integration.

3 CONCEPTUAL SYNOPSIS

In recent years, a discernible research trajectory has emerged focusing on the integration of Electric Vehicles (EVs) within smart cities. This strategic movement stems from the potential of EVs to contribute significantly to the mitigation of urban carbon dioxide (CO2) emissions, thus aiding in the reduction of environmental impact.

3.1 Historical Development of Electric Vehicles

In the study conducted by Anderson and Anderson in 2005, the evolutionary trajectory of electric vehicles (EVs) becomes apparent, tracing their development as a collaborative endeavor involving diverse scientists, each contributing significantly to their progression. The historical timeline of EVs can be segmented into three distinct periods: an initial era spanning from 1890 to 1929, marked by their early dominance within the market from approximately 1895 to 1905; an intermediate phase from 1930 to 1989; and the contemporary years from 1990 to the present day. The origins of EVs are rooted in the emergence of batteries, which marks the inception of their early history. In 1821, the English chemist Michael Faraday introduced the world's inaugural electric motor, followed closely by the practical application of Faraday's motor to rotate a wheel by the English mathematician and physicist Peter Barlow in 1822. The creation of "the Faraday disc," the world's pioneering dynamo by Faraday in 1831, laid the foundation for generating electrical energy through mechanical means.

This forward momentum persisted with notable innovations such as the construction of an electric motor-powered drifter in New England, United States, in 1835, and the introduction of an electric locomotive to the public in 1838. In 1841, Davidson devised the larger Galvani locomotive; however, due to the prohibitive cost of disposable batteries and resistance from railroad workers, the invention failed to thrive. Concurrently, between 1832 and 1839, Robert Anderson conceptualized a battery-powered horseless carriage. Regrettably, the absence of rechargeable batteries hindered this invention from reaching the market. A pivotal breakthrough arrived with the efforts of Dutch chemistry professor Sibrandus Stratingh, who developed a more efficient and practical battery-powered carriage. While it displayed enhanced performance, issues like noise, smoke, and discomfort persisted. Over time, Belgian scientist Gaston Plante addressed the challenge of recharging batteries, effectively overcoming the limitation of their inability to recharge post-depletion. This led to the successful creation of the first EV powered by rechargeable batteries in 1881.

Thus, the evolution of electric vehicles (EVs) encompassed a series of crucial contributions from scientists and inventors, culminating in the realization of rechargeable battery-powered automobiles. In 1881, Gustave Trouve introduced a three-wheeled EV to the public in France. Subsequently, in 1882, an English company emerged to produce rechargeable batteries, while Thomas Edison in America worked on an innovative battery type employing nickel-iron. Between 1910 and 1925, substantial advancements in battery technology materialized: battery storage capacity increased by 35%, service life improved by 300%, and maintenance costs plummeted by 63%. EVs proved to be cleaner, odorless, quieter, easier to initiate, less intricate, and more convenient in comparison to horse-drawn carriages or internal combustion engine vehicles (Burton, 2013). In 1894, the collaboration of Henry Morris and Pedro Salom yielded an "electrobat," a two-person transportation vehicle. Recognizing its potential, Isaac Leopold Rice, president of the Electric Storage Battery Company of Philadelphia, proposed a joint venture with Morris and Salom. Subsequently, the

Electric Vehicle Company (EVC) was established, concentrating on the manufacture of both batteries and EVs. The first commercially viable EV was produced at the Columbia factory in Hartford, Connecticut, and unveiled in May 1897. Shortly after, a service station for charging infrastructure was inaugurated in Newport. From 1897 to the summer of 1899, Columbia manufactured several hundred EVs for both domestic and international markets.

3.2 Overview of Electric Vehicle Adoption in the Developed and Developing Countries

Lambert (2022) posits that the advancement of electric vehicles is gaining momentum across the majority of developed nations worldwide. Presently, the global roads host a fleet of over 16 million electric vehicles (EVs), with a predominant 90 percent concentration observed in China, Europe, and the United States. Notably, various countries, particularly those classified as developed, have demonstrated remarkable progress towards the widespread adoption of EVs. Fortuna (2019) identifies the leading 15 nations in terms of EV market share, all of which are European countries. Norway emerges at the forefront with an impressive 82.7 percent market share in the first half of 2021, followed by Iceland (55.6%), Sweden (39.9%), Finland (28.3%), Denmark (26.8%), Germany (22.1%), Netherlands (19.7%), Luxembourg (18.3%), Switzerland (18.2%), Austria (17.2%), France (15.5%), Portugal (15.4%), Belgium (15.3%), the UK (14.9%), and Ireland (13.4%). While the United States (US) does not claim a spot within the top 15 countries in terms of EV market share, it stands as the third-largest market, trailing behind China and Europe. Notably, by 2020, Europe has superseded China, holding the consistent record of dominating the global electric vehicle market in terms of sales growth since 2012 (Perkins, 2021).

Furthermore, the transition from internal combustion engine vehicles (ICEVs) to more ecologically sustainable EVs has gained acceptance in numerous developed nations across the globe. Scholars such as Carranza et al. (2014), D'Egmont (2015), and Olson (2018) conducted studies on EV adoption in Norway, revealing that while the country faced obstacles such as elevated EV costs relative to ICEVs and insufficient charging infrastructure, these challenges could be surmounted through strategic incentives and a well-defined plan for establishing adequate charging networks. In a study exploring electric mobility in Europe, Biresselioglu et al. (2018) identified impediments to widespread EV adoption, including a dearth of charging infrastructure, escalating electric vehicle prices, extended charging durations, heightened electricity consumption by EVs, and scarcity of battery raw materials. Greene et al. (2014) delved into the transition to EVs in the United States and concluded that factors inhibiting the shift included uncertainties surrounding EV technology and the limited influence of governmental regulations. They also emphasized the importance of forthcoming studies to address EV-related uncertainties, thus providing a foundation for policy formulation. Vassileva and Campillo (2017), in their analysis of EV adoption barriers in Sweden, deduced that the absence of a robust incentive structure acted as a potential hindrance. Overall, the trajectory is clear: the majority of developed nations are embarking on the path of adopting electric vehicles as a prominent alternative to fossil fuel-dependent vehicles.

3.3 Electric vehicles adoption in the Developing countries.

Between 2015 and 2020, the market share data concerning new electric vehicle (EV) sales in "other countries" (excluding China, Europe, and the United States) remained below 2%, underscoring the prevalent challenges that many countries, particularly those in the developing sphere, continue to encounter in their quest for EV adoption (IEA, 2021). The insufficiency of a well-established market structure, network infrastructure, and robust economy stands as the chief explanation for the lag in EV adoption within developing nations, as elucidated by Asif et al. (2021).

Prakash et al. (2018) delved into the impediments faced by India, a developing country, regarding widespread EV adoption, identifying barriers that encompassed, among other factors, inadequate charging infrastructure, absence of governmental incentives, and customer traits. Similarly, Asadi et al. (2021) undertook a study exploring factors influencing EV adoption, revealing that range anxiety, post-sales support, and a dearth of charging infrastructure were the principal roadblocks to progress in Malaysia's EV adoption journey. Bigot (2020) turned attention to Russia, uncovering the slow integration of EVs, primarily attributed to the elevated cost of EVs, harsh winter conditions, and a deficiency in charging infrastructure. Encouragingly, Bigot also revealed a promising trajectory, as Russia's charging infrastructure is expanding, poised to surmount this barrier in the future.

Habich-Sobiegalla et al. (2018) concluded a study probing the intentions behind EV purchases in Brazil, pinpointing the elevated cost of EVs relative to internal combustion engine vehicles (ICEVs) and the inadequacy of public infrastructure to support their deployment. Moeletsi (2021), in a survey examining EV barriers in Gauteng, South Africa, brought forth the primary factors contributing to people's reluctance in acquiring electric vehicles—namely, the elevated purchase price and steep battery expenses.

However, although the pace of EV adoption in developing countries is arguably sluggish, with research in this domain still scarce (Asif et al., 2021), several developing nations have set ambitious targets and long-term strategies for EV integration. For instance, India has set an audacious goal to replace all ICEVs with EVs by 2030 (Chhikara et al., 2021; Das et al., 2019). Malaysia aims to establish 125,000 charging stations by 2030, while Thailand has laid out an extensive EV policy with the objective of having 1.2 million operational EVs and 690 charging stations by 2036 (Schröder et al., 2021). In Africa, South Africa is ambitiously targeting to account for 1% of global EVs (Wilberforce, 2021). To conclude, it is evident that the pace of EV adoption within developing countries lags behind that of their developed counterparts, although various initiatives and strategic plans have been set in motion to bridge this gap.

4 METHODOLOGY

The review on the role of electric vehicles (EVs) in environmental sustainability and their potential barriers to adoption was conducted using the Prisma approach. To gather comprehensive information, the study drew upon the latest academic literature on the topic and supplemented it with case studies from selected countries. These case studies served as crucial sources of information for defining the methodology and identifying the main application testbeds. The primary objective of the proposed multilayer approach was to assess the impact of EV adoption compared to vehicles reliant on fossil fuels, specifically focusing on its contribution to maintaining and achieving a greener environment. Additionally, the study explored the prospects of EVs while also identifying the obstacles and challenges that hinder their widespread adoption.

5 FINDINGS

This section presents information on the contributions of electric vehicles to the environment, its prospects and challenges.

5.1 Prospects of Electric Vehicles in Greening the Environment

Climate change and greenhouse gas emissions have become increasingly serious in recent years and transportation has been identified as one of the greatest contributor to this menance. While transportation is an integral part of any country, it cannot be denied that it is also a significant contributor to greenhouse gases. Based on this, there is need to identify ways of curtailing these, especially in cities and countries with great automobile dependance. One of the ways of the ways of reducing the reliance on cars that uses fossil fuels which is one of the greatest contributor to environmental problems and increasing the greening of the environment is the use of electric vehicles. Below are some of the Pros/ Prospects of Electric vehicles in achieving a green environment.

- Energy Savings: Electric vehicles are particularly effective in conserving energy at lower speeds and in situations that involve frequent changes in driving dynamics. This characteristic makes cities an ideal target market for their adoption. As the generation of electricity is expected to become greener in the future, electric vehicles have the potential to significantly reduce greenhouse gas emissions. Given the ongoing global discourse on climate change, this becomes a crucial consideration. Notably, the transportation sector accounts for over a fifth of the European Union's greenhouse gas emissions and is the only sector experiencing emission growth. While there is still potential for reducing emissions per kilometer driven through improvements in internal combustion engines, achieving emission reductions beyond 50% necessitates the implementation of new technological solutions like electric vehicles. Compared to conventional vehicles, electric vehicles exhibit approximately 50% lower emissions based on the current average electricity supply. Moreover, additional environmental benefits can be realized as the carbon intensity of power generation continues to decrease through the integration of greener and renewable energy sources.
- Societal and environmental cost: A report by Tseng et al. (2013) stated that the overall emission costs associated with the lifetime of a car encompass three primary sources of emissions: upstream

production and disposal of car components, tailpipe exhaust, and upstream energy production. Collectively, these three categories of emission costs are commonly referred to as the societal and environmental cost over the vehicle's lifespan. Specifically, tailpipe emissions during the driving cycle contribute to the release of air pollutants that have detrimental effects on human health. A comprehensive study conducted by Michalek et al. (2011) focused on vehicular emissions across a wide range of vehicle types based on gasoline consumption. The study revealed that, except for electric vehicles (EVs), tailpipe emissions of greenhouse gases (GHGs) constitute more than 50% of the total lifetime GHG emissions for most vehicle types. Furthermore, these emissions have a significant impact on health outcomes, including mortality and morbidity, as well as adverse effects on the environment such as reduced visibility, crop loss, forest degradation, depreciation of natural resources, and material depreciation. Hence, the electric vehicle is considered accounts for the least in terms of societal and environmental cost.

- Reductions in Noise Pollution: According to the research conducted by Hatt et al. in 2020, electric vehicles (EVs) offer distinct advantages over gas-powered (internal combustion engine) vehicles, providing benefits to their users. Notably, experts in transportation and electricity, as highlighted by Noel et al. in 2018, have identified noise reduction and improved performance as the top three advantages of EVs.

One significant benefit is the reduction in noise levels associated with EVs. This attribute contributes to a more pleasant driving experience for individuals and helps maintain low noise levels within communities. By minimizing noise pollution, EVs offer a quieter and more peaceful environment for both drivers and nearby residents.

- Lower Maintenance: Electric vehicles offer significant advantages compared to vehicles that rely on fossil fuels, including reduced maintenance requirements and economic savings. Studies by Egbue and Long (2012) and Noel et al. (2018) highlight these benefits. According to Lin and Sovacool (2020), users of electric vehicles have reported lower maintenance needs and reduced operating costs, primarily due to the absence of fuel expenses and the availability of inexpensive electricity.

When electric vehicle owners were asked to assess the advantages of their ownership, "less maintenance" emerged as the second most popular benefit, as it translates to both monetary and time savings (Egbue & Long, 2012). The reduced need for maintenance not only contributes to financial savings but also allows owners to allocate their time more efficiently. From the foregoing, it can be asserted that electric vehicles is very vital in achieving a green environment through the reduction in various environmental problems such as pollution and overall improvement in human health.

5.2 Barriers to the use/adoption of Electric Vehicles

Despite the role of electric vehicles in greening the environment, there are numerous barriers in both the developed and the developing countries of the world militating its effective adoption. Below are some of the barriers to its use:

- High Cost of Acquisition: The substantial initial purchase cost stands as a major deterrent to the widespread adoption of electric vehicles (EVs) across a global spectrum of countries. To illustrate, Sidabutar (2020), in a study focusing on electric vehicle utilization in Indonesia, highlighted that the typical purchasing capacity for cars in the country rests around 200 million Rupiah. Comparatively, the most affordable electric vehicle available in Indonesia, the DFSK Gelora E, carries a price tag of 480 million Rupiah—a sum surpassing the average car purchasing power by more than 200 percent. Consequently, this fiscal discrepancy compels consumers in Indonesia to lean towards internal combustion engine vehicles as their preferred choice. The elevated cost of EVs primarily emanates from the lofty battery prices, particularly pronounced in developing nations that often rely on battery imports from China— a pivotal constituent in EV manufacturing (Umah, 2021).
- Insufficient amount of charging infrastructure/ stations: The absence of a robust charging infrastructure constitutes a substantial barrier to the widespread adoption of electric vehicles, as underscored by Raksodewanto (2020). Serving as the bedrock for providing the primary energy source for electric vehicles, charging stations play an indispensable role in facilitating their adoption. However, the existing infrastructure remains far from attaining the envisioned goal of 25,000 gas

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stations by the year 2030. Presently, a mere 200 operational charging stations exist, revealing a stark disparity due to the elevated installation costs, particularly prominent in most developing countries, with Indonesia serving as a prominent example.

The twin challenges of range anxiety and the dearth of adequate charging infrastructure frequently engender stress and unease among electric vehicle (EV) owners. The prospect of undertaking long-distance journeys amplifies these concerns, especially when navigating areas beyond urban domains, a concern illuminated by She et al. in 2017. The predicament intensifies when EV owners must rely on unfamiliar sites, such as hotels, often necessitating appeals for access to charging facilities, thereby compounding stress and uncertainty. In the context of Indonesia, the installed charging infrastructure remains notably inconsequential in comparison to the sheer volume of gas stations. This imbalance prompts prospective Indonesian electric vehicle buyers to deduce that the nation is yet to establish a comprehensive preparedness for transitioning to electric vehicles (Jati, 2021).

- The safety and performance of the lithium ion battery used in EVs are both notable barriers to purchasing and present a challenge once the EV has been purchased. One particular aspect that raises concerns among individuals is the performance of lithium-ion batteries in electric vehicles (EVs), primarily due to the lengthy charging time compared to the quick refueling process of gas-powered vehicles (Lin and Sovacool, 2020). Charging a battery in an EV may require several hours, posing a potential inconvenience to users. In addition to the charging time, safety represents another significant apprehension associated with the adoption of EVs, primarily due to the inherent risks of battery-related incidents. Instances of battery fires or explosions, particularly in the event of an accident, have been identified as valid safety concerns (She et al., 2017; Hatt et al., 2020). Ensuring the safety of EVs and their battery systems remains a key consideration for widespread acceptance and adoption.
- The performance and reliability of an EV once purchased are also a major barrier barriers to the widespread adoption of EVs. For example, one aspect that has raised concerns among electric vehicle users and experts is the durability of the battery and the potential need for replacement, particularly considering the high cost associated with replacing the lithium-ion battery. In relation to this, Lin and Sovacool (2020) highlighted the issue of reliability, particularly during the winter season, as the battery might require more frequent charging and longer charging times.
- Lack of model diversity: Studies have shown that electric vehicles face limitations in terms of price range and available features, leading to a lack of diversity. The options for consumers to customize their EVs according to their specific needs are limited. For instance, certain EV models may be too small and impractical for individuals with families, failing to meet their requirements. Additionally, there is a noticeable absence of functional diversity, particularly for those who require towing capabilities, as there are no current EV truck models available (Haddadian et al., 2015).

5.3 Sustainable Urban Mobility

Crafting a sustainable urban transport system encompasses the enhancement of multiple facets, including but not limited to mobility, accessibility, affordability, social equity, efficiency, safety, security, convenience, low carbon footprint, comfort, and harmonious coexistence with both people and the environment. Achieving this vision necessitates a comprehensive approach to address diverse challenges, which collectively encompass: the mitigation of urban air pollution, grappling with climate change, curbing the toll of road accidents, taming excessive motorization, bolstering public transportation services, fostering pedestrian and cycling culture, and acknowledging the distinct requirements of marginalized urban populations, women, the elderly, individuals with disabilities, youth, and children.

It remains pivotal to recognize that urban transport, or mobility, transcends mere isolation; its dimensions are intricately intertwined with various other aspects of urban existence. United Nations Environment Programme (UNEP) (2010) underscores that the transport sector stands as the second-largest contributor to global carbon dioxide (CO2) emissions stemming from fossil fuel combustion. Of this share, a significant 23 percent of CO2 emissions emanate from transportation, with road transport constituting a substantial 73 percent, trailed by international shipping and aviation. Paradoxically, transport's role in global climate change mitigation initiatives remains disproportionately limited in comparison to other sectors. Among the prominent environmental concerns, urban air pollution emerges as a pervasive hazard, casting a shadow over numerous locales.

	PM10 (µg/m3)	SO_2 (µg/m3)	NO_2 (µg/m3)
WHO Air Quality Guidelines:	20	20	40
Beijing	89	90	122
Delhi	150	24	41
Tokyo	40	18	68
Seoul	41	44	60
Mexico City	51	74	130
Bangkok	79	11	23
London	21	25	77
New York	21	26	79
Paris	11	14	57
Shanghai	73	53	73
Santiago	61	29	81
Sao Paulo	40	43	83

Table 1: Air pollution in selected cities. Source: World Bank, 2009

Table 1 presents the World Bank's comprehensive assessment of air pollution levels across select cities in both developed and developing countries worldwide. A striking trend emerges from the data: cities in developing countries consistently exhibit higher levels of various air pollutants in comparison to their developed counterparts. Despite this observation, only a handful of cities manage to adhere to the recommended thresholds established by the World Health Organization (WHO) to ensure air quality. Across the global landscape of cities, the road transport sector stands out as the primary contributor to urban air pollutants, alongside elevated levels of carbon monoxide and hydrocarbons, among other noxious substances. Consequently, these emissions play a substantial role in triggering an array of respiratory and cardiovascular afflictions. An array of epidemiological investigations have unequivocally linked pollutants stemming from transportation to ailments like asthma, bronchitis, heart attacks, and strokes. Those particularly vulnerable to the perils of urban air pollution include infants, the elderly, and individuals afflicted by chronic respiratory ailments. For instance, as reported by Majumdar (2010), a staggering 25.6 percent of children in Bangalore, India, experienced asthma between 1999 and 2009. Furthermore, according to the World Health Organization (WHO) (2008), air pollution is implicated in nearly 2 million premature fatalities globally, with road transport emerging as a substantial contributor to this grim toll due to its role in exacerbating outdoor air pollution.

To effectively combat these issues, it is imperative for cities to recognize that concerted, collective actions are essential, aligning with global mitigation objectives. Adopting a diversified array of measures rather than relying solely on a single approach yields manifold advantages. This multifaceted strategy encompasses:

Push and Pull approach:

Examining the predicament through the lens of "where" individuals should position themselves in the realm of transportation—effectively where to "guide" them—and discerning which modes warrant their engagement, constitutes a methodological perspective referred to as the "push and pull" approach. This approach underscores the necessity for urban transport strategies to not only incentivize the public to opt for public transport and nonmotorized alternatives but also to devise tactics that gently nudge them away from the confines of automobiles and analogous modes of transport. Attaining the "pull" dimension entails delivering a commendable standard of service within public transport, erecting robust infrastructures catering to public and non-motorized modes, and implementing policies that enhance the usability of these modes. Concurrently, achieving the scenario where individuals are "restrained from car usage" necessitates the enactment of policies designed to discourage vehicular reliance. Such policies encompass the termination of fuel subsidies, the establishment of fees associated with automobile ownership and operation, and a comprehensive implementation of measures that escalate the overall costs incurred by utilizing these modes. Critically, the revenue generated from these charges should be channeled to reinforce the sustainable urban transport alternatives.

Public Transport, Non-motorized transport, Transport demand management, and Transit oriented development: An alternative perspective on implementing sustainable urban transport hinges upon the utilization of the four delineated measures. Public Transport represents a pivotal dimension of this approach, necessitating the creation of robust public transport systems, encompassing the establishment of comprehensive mass transit networks. Within this ambit, the Bus Rapid Transit (BRT) system has emerged as a favored solution in recent years, celebrated for its moderate implementation costs, expedited setup, exceptional service quality, and impressive passenger capacity, thereby translating to diminished vehicular congestion. Additionally, other rapid and ecologically benign urban passenger transport systems such as subways and light-rail configurations ought to be embraced as supplementary transport modes, thereby encouraging the establishment of multi-modal transport systems.

For instance, a notable 116 cities, predominantly situated in industrialized nations, operate their own metro systems, catering to an estimated daily ridership of 155 million individuals. Furthermore, approximately 400 light rail systems operate worldwide, with a staggering 200 additional systems currently in the planning phase. Many burgeoning megacities in developing nations are also directing investments toward the establishment, enhancement, and expansion of urban light-rail networks. Despite the formidable construction and maintenance expenses associated with metro and urban light-rail systems, they offer substantial, far-reaching benefits across the economic, social, and environmental spectrums. Non-Motorized Transport, alternatively labeled as "Active Transport," encapsulates pedestrian and cycling modes, as well as their associated infrastructure, policies, and educational initiatives. In recent times, these modes have gained notable traction due to their pronounced merits in curbing transport emissions and bolstering human well-being (Godefrooji et al., 2009).

Transit Oriented Development: This concept pertains to an urban design strategy characterized by policies that endorse intensified urban development along mass transit corridors (Cervero, 1998). The underlying logic driving this approach is rooted in the potential for substantial gains in energy efficiency and transport efficacy achieved through urban layouts in which mass transit networks enable swift connectivity to key urban hubs encompassing residences, workplaces, educational institutions, recreational venues, and healthcare facilities.

Avoid, Shift, Improve Framework:

- Avoid: The initial strategy centers on curtailing unnecessary travel and minimizing trip distances. This entails seamless integration of land use and transport planning, the promotion of mixed-use developments, and leveraging information and communication technologies (ICT) to curtail individual travel frequency. Strategic implementation can effectively augment accessibility, curbing travel distances and durations. Achieving proximity between residences, workplaces, and commercial centers through comprehensive urban development master plans is a pivotal facet. Furthermore, this approach capitalizes on the potential of ICT to replace activities previously mandating physical travel. Given its potential for profound social, economic, and environmental benefits, the "Avoid" strategy takes precedence, as its comprehensive application can significantly transform urban transport dynamics.
- Shift: The subsequent strategy is dedicated to facilitating a transition towards more sustainable transportation modes. This entails encouraging automobile and motorcycle users to pivot towards public and non-motorized alternatives. Leveraging an array of travel demand management tools, the strategy orchestrates an enhanced development of both inter-city passenger and cargo transport. Moreover, it cultivates an environment that retains existing public and non-motorized transport users, acknowledging their role in promoting sustainability. Properly executed, the "Shift" approach ranks as the second most potent avenue for instating sustainable urban transport. When Avoid and Shift strategies synergize within a city, the foundation for transformative change is laid, although continued enhancements remain feasible.
- Improve: The final strategy revolves around policies that seek to elevate transport practices and technologies, embracing a technological perspective to address urban transport challenges. This encompasses refining fuel quality, enhancing vehicle fuel efficiency standards, instituting vehicle emission regulations, introducing vehicle inspection and maintenance (I&M) protocols, and transitioning towards "intelligent transportation systems" capitalizing on information and communication technologies for enhanced transport management. This strategy also underscores the urgency of refining freight transport technologies and logistics for comprehensive transformation.

Overall, even though the success rate of electric vehicles in achieving sustainable transportation planning is enormous, there is a need to explore other measures which will promote sustainable planning, especially in the developing countries of the world where the rate of adoption and utilization of electric vehicles is low.

6 CONCLUSION

Transportation stands as a pivotal conduit linking individuals, locations, commodities, and services, fostering community growth, augmenting quality of life, and nurturing economic vitality. However, it concurrently serves as a noteworthy contributor to greenhouse gas emissions. In response, the global arena is actively endeavoring to address these challenges by pivoting towards greener energy sources and transitioning from fossil fuel-propelled vehicles to electric alternatives. Nevertheless, the widespread adoption of electric vehicles (EVs) remains an intricate challenge, particularly in developing nations. Obstacles encompassing inadequate charging infrastructure, elevated EV costs, and limited public awareness collectively hinder the swift embrace of EVs. By discerning the paramount catalysts and impediments in electric vehicle adoption, these nations can strategically chart pathways to surmount these barriers and bolster the integration of electric vehicles into their landscapes. Additionally, alternative sustainable transportation methods such as such as integration of all modes of transport such as the use of active travel/public transport in combination with other modes such as road, rail and air. Also, it is pertinent that to avoid total eradication of vehicles that use fossil fuels on our roads, there is a need to generate ways to adapt fossil fuel vehicles to use of renewable energy. This will allow road users/motorists to focus on diverse options instead of a single track which is not beyond human ingenuity.

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