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Research Article

TRANSITIONING TO GREEN: OVERCOMING BARRIERS TO ADOPT ELECTRIC SCHOOL BUSES IN THE US K-12 EDUCATION SYSTEM

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Abstract

The demand for transportation continues to grow with the rise in population and so do the demand for and consumption of fossil fuels adding tothe already elevated levels of pollution. School buses are specifically anarea of concern, contributing excessively adversely to the ambient air quality, causing pollution in the vicinity of schools and residential zones, while their emissions gather inside the passenger cabins. The transition to battery-driven electric vehicles (BEVs) or electric school buses (ESBs) has become necessary especially for school transportation to ensure a healthier environment for the students who currently use internal combustion engine (ICE) buses to commute daily. Adoption of these ESBs will also enable a smooth transition into the K-12 transportation system in the US which emerged and gained popularity in the COVID times. This research article explores the challenges and opportunities involved in transitioning from conventional ICE school buses to EV school buses and the approaches that can be adopted to mitigate the problems of implementing it in the K-12 transportation system, the largest mass transit system in the US.

Keywords: Electric vehicles, Electric buses, ESBs, EVs, Iconic, Yellow, School buses, BEVs, Yellow school buses ICE, Transition.

INTRODUCTION

The yellow school buses, considered to be iconic when it comes to public transportation in the US, carrying school children to and from their schools were not only responsible for commutation of school children but also for causing health damages to the kids. The lion's share of the fleet consists of diesel-poweredinternal combustion engine (ICE) vehicles which are notorious for causing environmental pollution, and are noisy too. At the global level, there is a massive demand for energy that fuels transports, which is continuously growing and met primarily by liquid fuels derived from petroleum that power the ICE vehicles (Kalghatgi, 2019). This has resulted in the government, industry, and academia actively promoting the development and adoption of an electric vehicle (EV)-based transportation system (Kumar, et al., 2023).This article highlights the problems associated with the deployment of electric school buses and the generates useful insights to give an indication of what could be done to ensure successful adoption of ESBs.

LITERATURE REVIEW

This article scrutinizes various literature, available publicly, on ICE school buses, their effects and problems of deployment of ESBs in the US, to better understand and highlight the problem areas associated with ICE School Buses and the deployment of electric school buses. The resources include journal articles, reports issued by renowned agencies, newspapers, magazines and other publications, government and private websites.

Conventional ICE School Buses

The iconic yellow school buses, an integral part of American culture, was relied on for communication of school children. Over half a million (480,000) school buses in the United States transporting about 26 million students to and from school(FHA, 2019) travelling nearly 3.5 billion miles (Arora, et al., 2021). These yellow school buses help to spare as much as 2.3 billion gallons of fuel which helps the families save over $7.3 billion from being spent as fuel costs per year (NYSBCA, 2024).The yellow school bus fleet is the principal public transportation fleet in the U.S. and is 2.5 times the combined number of vehicles of every form that is usedforpublic transportation (DMV List, 2020).There are several children who are devoid of any alternative mode of transportation and hencedepend heavily upon the yellow school buses for getting to their schools. Nevertheless, the school bus technologies presently in use (ICE) pose significant short- and long-term environmental and healthhazards (Arora, et al., 2021). Today, in the US, over 90 % of the school buses on the road are powered by diesel, and the growing concern for children's health and the environment have resulted in an increase in interest in ESBs in the recent years (APP 2022).

Effects of Using ICE School Buses

ICE school buses, though largely in use today as the most popular mode of commutation by school children, are potent sources of emission which comefrom diesel - a fuel that is being used by 95 % of these conventional yellow school buses. These emissions have been found to be damagingtothe lungs of the young ones besides having other unfavorable health impacts and the planet (International Trade Administration, 2024).The vast majority of the school buses in the aging fleet of the country are powered by fuels such as diesel, propane fuelsor gasoline. All of these fuels, on combustion emit pollutants that meet the hazardous criteria and also discharge greenhouse gases (GHGs) into the atmosphere (Arora, et al., 2021) . The conventional diesel-poweredICE yellow school buses produce significantly large volumeof air pollution in the form of harmful particles that, when breathed in, are able to

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pass directly into the bloodstream causing significant damage to the body;they also release other pollutants into the air that are believed to be the precursors to formation of ground level ozone, that is an irritantof the lungs (Hailstone, 2021). These pollutants besides contributing to the anthropogenic climate change can be potentially hazardous to thestudents' health having long-term adverse effects on health of students that ride in and around school buses (Arora*, et al.,* 2021). Traffic-related pollutants affect student health greatly. Pollutants related to traffic around schools, such as, nitrogen dioxide, elemental carbon, and particulate matter have significant bearing on the respiratory system of students, developmental nervous systems and their cognitive abilities. High concentrations of these elements have been seen to result in increase of tracheitis, asthma, respiratory infection, and other diseases in children as also affect their cardiovascular systems and are relatedto allergic symptoms (An, *et al.,* 2021).

Certain studies that had been carried out in the past have indicated that sitting inside a bus can be potentially more damaging as it exposesthe person to higher air pollution compared to the person who is outside that bus (Hailstone, 2021). Compared to the outside environment, the degree of pollution within the iconic yellow school buses are likely to be up to 10x higher (Skibell & E&E News, 2021). The pollution from tailpipe of a diesel bus can get trapped within the cabin and cause adverse impact on the health of the people sitting inside.Prolonged exposure to pollution from diesel-powered buses can be detrimental to the normal lung development of the children and put them at a disadvantage over the long-term as they are breathing the same polluted air everyday while sitting inside the bus (Hailstone, 2021). children who have a faster breathing rate than adults and whose lungs are not yet fully developed (EPA, 2023).Students can spend up to2 hours per day in a school bus, and innately get higher exposure to pollutants by just sitting inside a school bus than they would by being inside a car, since the doors keep opening and closing repetitively (Skibell & E&E News, 2021). Along with the emissionsthe conventional ICE school buses are also very very noisy, specifically to the passenger (Hailstone, 2021).

Need for ESBs

The U.S. transportation sector has the reputation of being the key cause of the major source of pollution for the climate. At around just 480,000, theschool bus fleet comprises only a small fragment of the aggregate number of vehicles in the US that possess diesel engines. It forms a slice of the US transportation sector to which children get the most exposure, because of the simple reason that these vehicles are constantly going to be in the close proximity of these children - parked idle outside their schools, driving up and down the roads in the areas of their residence, and the children commuting inthose school buses (Hailstone, 2021). Electrification of this sector is expected to help in cleaning up air pollution in almost all major cities in the US. This is likely to be beneficial in more than oneways. The transition from ICE school buses to EV electric school buses is a significant step towards moving away from pollution caused by fossil fuelcombustion since the lion's share of the current fleet uses diesel to run on (Hailstone, 2021).Buses being really huge in terms of spaces which makes it really difficult to filter the ambient air in a manner that wud be the same as the one used to filter the air inside the cabin of a car. This, however, does not even factor in the emissions caused by the school bus itself, which is spread toxic emissions that are the obvious outcome ofthe internal combustion process (Marshall, *et al.,* 2019). For addressing the negative impacts resulting from the use of school buses powered by fossil fuels, school districts, government agencies, and school bus manufacturers have already launched the demonstration of the electric school bus (ESB) technology (Arora, et al., 2021) . An experiment showed that on riding buses that use cleanerfuels and / or clean air technologies, the school children experience reduced exposures to air pollution, lower pulmonary inflammation, lung growth over time that is muchfaster, which reduces absenteeism compared to when they are commuting in buses that do not use these technologies and fuels (Adar, et al., 2015).

There are several advantages of deploying EVs for school transportation whencompared with the typical school buses that run on diesel fuel.Not only do the ESBs have the potential to bring downthe costs associated with operations and maintenance of fleets but they also have nil tailpipe emissions. Because of the huge size, their batteries,employing the "vehicle-to-everything" technology, will be able to store as alsosupply power to buildings and provide the energy necessary to power other devices. This will support superiorflexibility through renewable energy integration. ESBs are also potential income earners. They can generate revenue through the discharge of energy back onto the grid from their batteries, lowering utility costs and emissions. As of now ESB market is at abudding state and the ongoing technological progressionis expected to make electric vehicles in general and electric school buses in particular, widely available in the near future (HUNTINGTON, *et al.,* 2022). By their very nature, the school buses in the U.S. are very well positioned to transition to electricity run vehicles. These vehicles are, at present, usually used twice a day – once in the morning to pick up school kids from home and drop them off at school and then once in late afternoon to drop them back home. The rest of the day they remain idle. During these hours when they are off the road they can be charged and recharged (Hailstone, 2021). Their excess unused power can be sent back to the grid which can provide them with extra income.

Problems in Deployment of ESBs

Deployment of electric buses is very different from that of diesel buses and hence requires different kind of decision-. It also makes planning for their charging infrastructure a complex job. That is why it becomes imperative for the entities involved in the transition, such as transit agencies and school districts, and operators of other bus fleet to makeupfront investment in resources to draw appropriate plans. Apart from planning for upfront costs, adoption of BEBs and ESBs asks for an updated fleet design together with the development of staff capabilities needed for operating and maintaining these electric school buses. In addition, there will be various operational challenges including theinconsistency of battery range and rate structures associated with the consumption of electricity (US Dept of Transportation, 2023).

Inadequate Availability of Power

The demand for EVs in general has outstripped supply. Along with that there has been inadequate development of infrastructure in terms of development of charging infrastructure. Also, there is an issue with the adequacy of green sources of energy. Electrification will only make sense if

the electricity itself comes from sources that are green (Jaiswal, et al., 2022). The challenge with theexisting power grid system is that it is not completely cleanbecause of the use of various different types of fuels which must be transitioned to greener renewable energies. Additionally, the entire system has to be updated in order to make it sturdy enough to handle the added requirement of power for electric vehicles (TBD Media Group, 2023).

Demand Supply Mismatch

Execution is another challenge since a balance hastobe maintained betweenthe local and the federal of it (Hailstone, 2021). For a number of transit agencies, federal grants can prove to be helpful as theyprovide thepush to their plans that isnecessary to make them changeover to electric buses and cut down the emissions generated carbon-intensive bus fleets. However, the demand for all-electric buses significantly surpasses the sum of money that the government has appropriated for these transit agencies. For the time being, money that has been set aside specifically for buses that though run on fossil fuel are low on emissions, stays unavailable to transit agencies that are contemplating on takingthe 100 % zero-emissions route (John, 2023).

High Initial Capital Cost

Among the cons of switching over to EV technologyis the initial higher cost of capital. It goes without saying that compared to the baseline buses, the battery electric buses tend to be more expensive at initial time of buying the vehicle (US Dept of Energy, 2023). The strategy to deploy green and hence clean school buses are also likely to be held up by the inability of the utility companies to rapidly build, scale up and power the required charging stations (Lee, 2024). The

Inadequate Charging Infrastructure

Among the key challenges faced in the implementation of EV charging in multi-unit projects the largest is the availability of adequate utility infrastructure. Installation of the EV charging infrastructure is much less costly if it is done at the time of construction of a new building. It is an expensive affair toinstall the same infrastructure at the time of renovating the building. Much of this cost increase is because of theadditional permitting costs, demolition, and trenching (US Gov - Department of Transportation, 2023).

Large Scale of Operation

Another prominent problem in deployment is the scale of operations. Handling the transition for 3-4 buses is never problematic but handling a huge fleet is. problem of adequate electricity supply is also there. The supply of electricity needs to be robust enough to give the EV owners enough of the power that they need to provide undisrupted service. Technology is also required for controlling the charging in order to make sure that you've got enough range to deliver the service (TBD Media Group, 2023).The availability of the necessary electrical power for powering up the complete fleet is one of the major challenges for everyone involved. Buying an electric school bus comes much later, rather has much lower priority, in the planning cycle. It is all about having the electrical capacity to drive the school bus fleet conversion to meet your state mandate (Karam, 2023).

DISCUSSION

Drivers of school buses, school staff, students as well as the community members, all can draw benefits from the implementation of low- and zero-emission vehicles through the deployment of electric school buses. The employment of electric school buses will help to improve the ambient weather by providing cleaner air on the bus for the students and the drivers to breathe in, all along the bus route and also in areas used for loading. Thus these green buses would also benefit the communities in which they operate. As promising as it sounds, deployment of green transportation, especially electric school buses is not going to be an easy job. A couple of key concerns are the availability of sufficient number of electric buses and the existence of a conducive environment and that includes the necessary infrastructure (TBD Media Group, 2023). As is clear from the literature review, conversion of a fleet of conventional ICE school buses to all-electric school buses does not simply involve the purchase of new vehicles and acceptance of the charge they provide. A proper transition from ICEs to BoVs (battery operated vehicles) involves taking care of several aspects such as the myriad of operational strategies and the plethora of infrastructure requirements that will arise during the course of the transition. This includesdeciding the location or placementof the chargers, the type or variety of the charger that would be required and used, and deciding the ownership of the charging system (Electric & Hybrid Vehicle Technology International, 2020). These challenges can usually be met through early and constant coordination with resident utilities and assessment of the opportunities available for the utilization of power sources that are off-grid.

The initial capital expenditure can be a daunting task for many. While there are significant costs involved in installation of the charging infrastructure in a building, a large many of these costs can usually be circumvented if the installations are done while the building is being newly constructed rather than retrofitting the buildings with the charging infrastructure. Another way of reducing the costs associated with charging would be shared micromobility charging which makes charging the electric vehicle possible at lesser cost per end user (US Gov - Department of Transportation, 2023). It is for the fleet managers to choose to invest in what makes the most sense to meet their priorities, considering the high up-front costs and the problems associated with the inadequacy of the power supplied to the charging stations for charging the EVs. Optionssuch as en-route charging are available to the fleet owners and this option can be effectively usedfor extending the daily range of the buses. Fleet owners can also go for managed-period charging instead of unmanaged charging.

Management of the demand for electricity is a crucial factor that needs to be considered at the time of designing the charging infrastructure that can, not only facilitate transition from the conventional ICE yellow school buses to battery-driven electric school buses, but also support the operations of a reliable fleet in a cost-effective manner. Charges for electricity demand beyond energy usage are fees that are levied on customers commercial and industrial on the basis of certain calculations made upon the maximum volume of power that is drawn during a normal 15-minute interval within the billing period (Eid, et al., 2016). Such feesaffect those customers like the electric school bus owners who have sizable electricity loads over a comparatively smaller span of time. Studies

focused on energy usage can help to distinguish those operating strategies and design which needs to level out energy usage and rationalize demand for electric.This will also help to keep the infrastructure costs at lower levels not only for the utility but also for the owner of the electric fleet. So far as the capacity of the grid to cater to large demand for electricity for charging the fleet is concerned, the fleet owners can always follow the strategy of having spare vehicles so that a portion of the fleet always remains charged. The entire fleet does not need to be charged at one go. The fleet owners can resort to charging a portion of the fleet at a time, especially during off-peak hours. Another option is to purchase and charge an on-site battery for storage of electricity or share a meter along with the relevant costs with another heavy user that has a matching electricity demand. Yet another option available to the fleet owners is choosing chargers with higher capacities that will facilitate the reduction in charging time per vehicle and would use similar kind of electricity demand as a number of lower capacity chargers that remain paired with separate vehicles for a longer period of time.

Controlling the demand for electricity is essential and a key to the successful employment of electric school buses for easy commutation of school children. Taking the right steps and reaching a decision right at the beginning can go a long way in avoiding atheoretically large electricity demand (and hence the charges associated with it) that will be extremely difficult to mitigate at a later time. Engaging operations staff of the school bus fleet during the early stages of transition will ensure a smoother process. It will also make sure that new issues are not created, time and again, to impact thepresent operations and things run smoothly even after the adoption of electric fleet. It goes without saying that looking for and striving to make the best possible efficient use of the resources at disposal can actually save quite a hefty sum of money over the lifecycle of the fleet.

Finally it is time for the school bus and transit bus fleets to take effective steps towards speedier adoption of electrified buses which makes it imperative for these entities to commencediscussions with their local electric utilities. In fact the conversations need to begin very early in the course of the planning process that will ensure adequate power is available as and when needed (US Dept of Transportation, 2023). Timely identification ofobstacles is crucial to addressing them before they spin out of hand to become major issues that are difficult to solve. There can be a plethora of challenges. These includeproposition, purchase of chargers, installation, and amortization, space constraints for both indoor and outdoor fleets, and uncertainty related to the availability of the government grants (initial costs to be incurred for transitioning from ICE vehicles to EVs can be daunting for many fleet owners) and the need for training the existing staff to ensure smoother transition (Karam, 2023). So far as the funding side of the transition is concerned, both the federal government and the local authorities are trying to provide adequate assistance to encourage the local school bus fleet owners to actively participate in the changeover. In 2022, the US Environmental Protection Agency (EPA) provided funds in excess of $875 million for the replacement of 2,366 ICE buses across 372 school districts (Lee, 2024). A $1.7 billion grant was announced by the U.S. Department of Transportation in June last year for bus decarbonization projects (John, 2023). Another $1 billion was announced in January 2025 for school districts to replace diesel buses with cleaner versions, including electric buses (Joselow & Phillips, 2024). For a vast majority of the transit agencies, such grants can supply significant boost to the plans of the transit agencies to change over to electric buses and cut down emissions from the prevailing ICE bus fleets that are hugely carbon intensive. Unfortunately, the demand for pure electric buses is far greaterthan the volume of money that the US Government has set aside for themwhile, money that is being held in reserveparticularly for buses running on fossilfuels yet arelow on emissions, remains unavailable to these transit agencies that want to transition to the complete zeroemissions route.

Conclusion

There is no doubt that the iconic yellow school buses of America had provided valuable services to the economy. They have made commutation easy for the school children, especially the ones belonging to low-income families. Yet these buses played a significant role in heightening air pollution and have been proved to be particularly harmful for the commuters sitting inside. A drive for clean transport, as an off-shoot of desperate attempts at cleaning up the environment as global warming continues to worsen, has made it essentials that the traditional pollution emitting ICE vehicles be replaced by vehicles run on electricity. The replacement of ICE school buses by ESBs is a part of that drive. Several challenges exist when it comes to deployment of these EVs. Demand-supply mismatch, inadequate charging infrastructure, high initial costs, shortfall in power supply, limited availability of green power and to top that management of large scale transition of school bust fleet. The government and local agencies continue to remain committed to change and provide financial assistance to the fleet owners. While the market for electric mobility continues to grow substantially, at a rapid pace, charging infrastructure also continues to expand even as several key challenges persist. Planning is very important especially when the fleet owners are faces with several constraints. It is a complex process and the pace needs to be steady. The adoption of electric buses by transit agencies is not a simple decision – it does not involve simple switching over from diesel bus to an electric one but involves challenges that need to be considered, including planning for upfront costs and staff capabilities to operate and maintain these assets,in addition to the operational challenges such as theinconsistency of battery range and electricity rate structures. Nevertheless, the change is impending and the only way forward.

REFERENCES

Adar, S. D. et al., 2015. Adopting Clean Fuels and Technologies on School Buses. Pollution and Health Impacts in Children. *Am J Respir Crit Care Med.,* 191(12), pp. 1413-1421.

An, F., Liu, J., Lu, W. & Jareemit, D., 2021. A review of the effect of traffic-related air pollution around schools on student health and its mitigation. *Journal of Transport & Health,* Volume 23:101249.

Arora, M., Welch, D. & Silver, F., 2021. *Electric School Buses Market Study: A Synthesis of Current Technologies, Costs, Demonstrations, and Funding,* s.l.: CALSTART.

DMV List, 2020. *School Buses as the Largest Transit System in the US (recent stats).* [Online] Available at: https://dmvlist.com/auto-blog/2020/03/03/school-buses-as-the-largest-transit-system-in-the-us-recent-stats/[Accessed 04 Apr 2024].

Eid, C. et al., 2016. Time-based pricing and electricity demand response: Existing barriers and next steps. *Utilities Policy,* Volume 40, pp. 15-25.

Electric & Hybrid Vehicle Technology International, 2020. *How to design charging infrastructure for an electric fleet.* [Online] Available at: https://www.electrichybridvehicletechnology.com/opinion/qa-how-to-design-charging-infrastructure-for-an-electric-fleet.html [Accessed 09 Apr 2024].

EPA, 2023. *Reducing Diesel Emissions from School Buses: U.S. Environmental Protection Agency.* [Online] Available at: https://www.epa.gov/dera/reducing-diesel-emissions-school-buses [Accessed 08 Apr 2024].

FHA, 2019. *2017 National Household Travel Survey,* Washington DC: Federal Highway Administration, U.S. Department of Transportation.

Hailstone, J., 2021. Is It Time For The Humble Yellow School Bus To Go Green?. *Frbes*, 09 Dec.

HUNTINGTON, A. et al., 2022. *Electric School Bus U.S. Market Study and Buyer's Guide: A Resource for School Bus Operators Pursuing Fleet Electrification,* Washington DC: World Resources Institute.

International Trade Administration, 2024. *Turning the Yellow School Bus Green through Innovation.* [Online] Available at: https://www.google.co.in/search?q=what+was+the+problem+with+yellow+school+buses+in+the+US&sca_esv=4752484a868d0ce9&rlz=1C2ONGR_enIN981IN981&sxsrf=ACQVn09-hrLDpgffn2svl0IC7K-Esot5ag%3A1712411709867&ei=PVQRZvbONPThseMP7puK8AI&ved=0ahUKEwi24bPd3q2FAxX0cGwGHe [Accessed 04 Apr 2024].

Jaiswal, K. K. et al., 2022. Renewable and sustainable clean energy development and impact on social, economic, and environmental health. *Energy Nexus,* Volume 7, 100118.

John, J. S., 2023. *The US' billion-dollar EV bus program can't keep up with demand: Canary Media.* [Online] Available at: https://www.canarymedia.com/articles/public-transit/the-us-billion-dollar-ev-bus-program-cant-keep-up-with-demand#:~:text=But%20the%20demand%20for%20all,100%20percent%20zero%2Demissions%20route. [Accessed 11 Apr 2024].

Joselow, M. & Phillips, A., 2024. *Yellow School buses are going green with a $1billion investment: The Washington Post.* [Online] Available at: for school districts to replace diesel buses with cleaner versions, including electric buses. [Accessed 08 Apr 2024].

Kalghatgi, G., 2019. Development of Fuel/Engine Systems—The Way Forward to Sustainable Transport. *Engineering,* 5(3), pp. 510-518.

Karam, A., 2023. *"The Rose and the Thorns": Operational Challenges in Electrifying School Bus Fleets.* [Online] Available at: https://www.linkedin.com/pulse/rose-thorns-operational-challenges-electrifying-bus-alfred-karam-cdpt-tpvyc/[Accessed 12 Apr 2024].

Kumar, M. et al., 2023. Comprehensive Review of Electric Vehicle Technology and Its Impacts: Detailed Investigation of Charging Infrastructure, Power Management, and Control Techniques. *Applied Sciences,* 13(15).

Lee, S., 2024. *White House Awards $1 Billion in Grants for Clean School Buses: Bloomberg Law.* [Online] Available at: https://news.bloomberglaw.com/environment-and-energy/white-house-awards-1-billion-in-grants-for-clean-school-buses [Accessed 04 Apr 2024].

Marshall, G. J. et al., 2019. Thermal Management of Vehicle Cabins, External Surfaces, and Onboard Electronics: An Overview. *Engineering,* 5(5), pp. 954-969.

NYSBCA, 2024. *Go Green, Ride Yellow!: New York School Bus Contractors Association.* [Online] Available at: https://www.nysbca.com/fastfacts#:~:text=Go%20Green%2C%20Ride%20Yellow!,in%20fuel%20costs%20each%20year. [Accessed 04 Apr 2024].

Skibell, A. & E&E News, 2021. Electric School Buses Reduce Pollution, but New Infrastructure Deal Slashed Funding. *Scientific American*, 03 Jul.

TBD Media Group, 2023. *On the road to electrifying America's fleet of school buses: Reuters.* [Online] Available at: https://www.reuters.com/plus/tbd-media-group/on-the-road-to-electrifying-americas-fleet-of-school-buses [Accessed 08 Apr 2024].

US Dept of Energy, 2023. *Alternative Fuels Data Center: Flipping the Switch on Electric School Buses: An Introduction to Electric School Buses: Module 2 (Text Version):.* [Online] Available at: https://afdc.energy.gov/vehicles/electric-school-buses-p1-m2#:~:text=Some%20of%20the%20cons%2C%20when,will%20likely%20require%20added%20infrastructure. [Accessed 12 Apr 2024].

US Dept of Transportation, 2023. *Benefits and Implementation Challenges of Bus Electrification.* [Online] Available at: https://www.transportation.gov/rural/electric-vehicles/ev-toolkit/benefits-and [Accessed 12 Apr 2024].

US Gov - Department of Transportation, 2023. *Implementation Challenges and Evolving Solutions for Urban Communities.* [Online] Available at: https://www.transportation.gov/urban-e-mobility-toolkit/e-mobility-benefits-and-challenges/challenges-and-evolving-solutions [Accessed 12 Apr 2024].

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