Impact of Electric Vehicles on the Future E-Commerce Landscape: Challenges & Advantages

Priyank Kumawat

Supply Chain and Operations Management Professional
Oxnard, CA 93036, USA
kumawatpriyank@gmail.com

Received Nov 19, 2024, **Revised:** Dec 12, 2024, **Accepted:** Dec 25, 2024, **Published Online:** Dec 28, 2024
Reviewers: Anonymous Peer Review
Citation: Kumawat, P. (2024). Impact of Electric Vehicles on the Future ECommerce Landscape: Challenges & Advantages. *International Journal of Supply Chain Management, 13*(6), 46-54, https://doi.org/10.59160/ijscm.v13i6.6282

***Abstract*— The E-commerce landscape has seen a paradigm shift with an increasing demand for door-step delivery and even same day delivery. The convenience of shopping over a handheld mobile devise from the convenience of one's preferred location is a major driver for the phenomenon growth, development, and expansion of online shopping. The COVID pandemic led lockdowns acted as catalysts expediting this expansion. But with this progress came the menace of rapid expansion of delivery trucks, vans, 3-wheelers, and 2-wheelers that increased not only the congestions within the cities but also added massively to the already deteriorating air quality. Pollution (both air and noise) and congestion, are the two immediate fallouts of the expansion in delivery fleet. This made the fleet owners and businesses turn to the obvious alternative – EVs or electrical vehicles that have the potential to not only cut down harmful emissions but also enhance financial and operational efficiencies. Modern businesses cannot help but improve efficiencies in order to sustain in an immensely competitive and dynamic business environment. This article adds to the literature on EVs and generates insight into the practicability of adopting EVs in the last mile logistics. It highlights that despite being both environment and pocket friendly, the benefits of economy and efficiency looks futile in the face of inadequate availability of charging infrastructure that heightens range anxiety.**

***Keywords*—** *EVs, electric vehicles, last mile, last-mile delivery, e-commerce, delivery, logistics, online, retail, online retail, shopping, online shopping, pollution.*

1. Introduction

E-commerce is the new face of retail in modern era. A massive number of businesses, big and small, took to the online format spooked by the global pandemic to ensure survival. But even before the pandemic, the progresses in the Information and Communication Technologies (ICT) space were increasingly pushing people towards online shopping. Proliferation of hand-held smart devices and the expansion and easy availability of internet are the key catalysts for rising number of online shoppers besides the convenience of shopping from home. COVID made the advantages of online shopping more apparent – zero-contact and doorstep deliveries pushed the number further up and more aggressively. But with it came the hassle of last mile delivery for the e-retailers. The significant rise in use of delivery vehicles has been one of the key reasons behind the increase in pollution. This article evaluates the use of EV in last mile delivery to tackle the problem of pollution and the possibilities of EVs becoming the future of e-commerce delivery. It also provides valuable insights into the advantages and challenges that are likely to be faced.

2. Literature Review

The landscape of contemporary trade and commerce is evolving rapidly with e-commerce emerging as a trailblazer. More than a third of the global population now shops online which has made the e-commerce industry highly enticing and

alluring [1]. Shopping online is hugely convenient which is why it has been able to transform consumer behavior so markedly and simultaneously create novel prospects for businesses to spread their wings across the globe. However, besides causing paradigm shift in the ways today's consumers shop, this digital revolution has an overpowering influence over strategies pertaining to logistics management, especially warehousing and transportation.

2.2 Increase in E-commerce over last 10 Years

During the COVID-19 pandemic, there was a dramatic rise in e-commerce amid movement restrictions. Online retail sales' share of total retail sales increased from 16% to 19% in 2020 [2]. International e-commerce sales reached $4.3 trillion in 2020 [3]. By 2021, e-commerce contributed to almost 18% of total global retail sales [4]. Global e-commerce sales are projected to cross $8 trillion by the end of 2024. In addition to this, according to the estimates made by experts, number of digital buyers across the world is set to rise from 2.14 billion in 2021, to 2.77 billion by 2025 [5]. The numbers are truly staggering. With the growth and expansion of e-commerce, there has been a significant rise in the demand for door-to-door delivery as well as e-fulfillment services [6].

2.3 Last Mile Delivery & Consumer Preferences

Thanks to this massive growth of ecommerce, consumers' expectations, so far as supply chain is concerned, have seen tremendous up move. Now-a-days consumers order a greater number of commodities online, with the expectation of exercising a greater control over delivery timelines, demanding swifter deliveries. Drones, droids and more such disruptive technologies are unsettling the whole delivery chains. Such incipient technology players as Uber Freight and Postmates are continuously altering the industry dynamics and hence changing the nature and intensity of the competition [7].

2.3.1 Expected Future Growth

According to the World Economic Forum, because of increased urbanization and the booming customer market for e-commerce, by 2030 the global demand for last-mile delivery is anticipated to go up by 78% [7]. In 2023, the market was estimated to be worth $164.74 billion and is predicted to grow at a CAGR of 10.37% to reach $357.45 billion by the year 2031 [8].

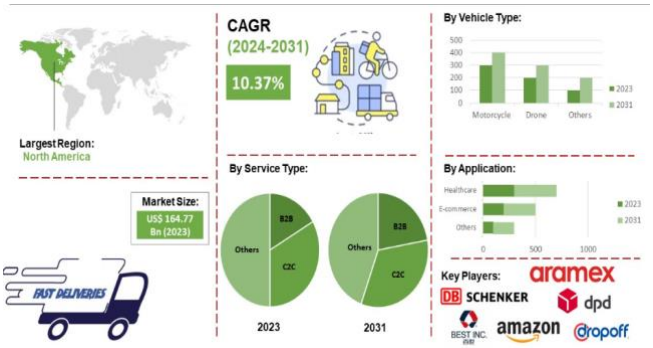

Figure 1: Global Last Mile Delivery - Present & Future [8]

Worldwide market for autonomous last mile delivery is projected to grow at a CAGR of 19.7% to reach $106.27 billion by 2034 from $17.45 billion in 2024 [9].

3. Methodology

This paper is based on secondary research that draws on data and theories from various published sources. The theoretical concepts are extracted from various books and journal articles while data is extracted from renowned sources, both public and private. Books, articles in peer reviewed journals, news papers and business dailies are the major resources. The paper also uses visual depiction to bring out the relevance of the theory.

4. Rise in use of Internal Combustion Engine (ICE) vehicles for last mile delivery

The exponential e-commerce growth has resulted in the increased employment of Light Goods Vehicles (LGV) for the delivery of parcels in urban areas [10]. It is anticipated that with the fulfilment of such mammoth growth in demand, the number of e-commerce delivery vehicles driving around inner cities could rise by 36% by the end of this decade, which means that there would be at least equal rise, if not more, in emissions, toxic waste, pollution and congestion [11].

4.2 Environmental Fallout

E-commerce and its continuous efforts to deliver the right products to the right customers at the right time have greatly enhanced the convenience of modern life. Companies like Amazon.com Inc., for example, offer next-day shipping at no extra cost, while services such as Uber Eats enable faster food delivery [12]. However, this convenience comes at a price.

4.2.1 Increase in Congestion

Cities and towns worldwide are increasingly grappling with congestion, as the rapid growth of e-commerce has led to a significant rise in the number of delivery vehicles. This surge in delivery fleets has caused a steady and notable increase in vehicle traffic, overwhelming urban roadways [12]. As the number of vehicles continues to rise, the infrastructure is being stretched to its limits, particularly in city centers, office districts, and school neighborhoods during peak hours, exacerbating traffic jams and causing gridlock. These high-traffic areas have become hotspots for vehicle emissions, contributing to uncontrolled air pollution.

Moreover, the prevalence of second-lane parking zones has further narrowed the roads, making congestion even worse. The exponential expansion of e-commerce over the past decade has significantly amplified these problems, intensifying both pollution and congestion. Researchers and policymakers in major cities agree that if no substantial actions are taken, urban traffic will experience severe disruption in the next two to three years [11].

E-commerce was initially designed to reduce consumer traffic by facilitating online shopping, thereby increasing convenience without adding to travel and congestion. However, the massive increase in online shopping has led to a surge in doorstep deliveries, resulting in more delivery vehicles—such as bulky mini-trucks and two-wheelers—on the streets. These vehicles contribute to traffic congestion, and since most of them run on diesel, they significantly increase carbon emissions and air pollution, even in the heart of cities. This growing pollution is diminishing the quality of life in urban areas, exacerbating health problems, particularly respiratory diseases caused by deteriorating air quality. As a result, the livability of cities is being negatively affected, turning urban dwelling into an increasingly difficult and undesirable experience [13].

4.2.2 Increase in Pollution

The rapid increase in the number and frequency of delivery vehicles on the streets is exacerbating the already significant problem of urban pollution. Diesel-engine delivery vehicles, in particular, are a major nuisance in urban areas, contributing not only to traffic congestion but also to noise pollution. Because doorstep deliveries are typically quick—entailing brief stops for alighting, delivering, and boarding—the drivers of diesel vehicles often leave their engines idling rather than turning them on and off repeatedly. This idling, coupled with the limited ability to shift deliveries to overnight hours, further compounds the problem. In addition to the noise pollution, this contributes to health issues such as elevated blood pressure, heart disease, and sleep disturbances [13].

At the current rate of growth, and without appropriate measures, vehicle emissions could increase by more than 30% in the world's top 100 cities by 2030, unless drastic actions are taken. Stronger policies and effective management will be essential to curb this rise [11]. In the U.S., delivery vehicles are among the primary contributors to air pollution, responsible for almost 50% of the nation's nitrogen oxide emissions [14]. Nitrogen oxide can elevate particulate matter, which is a key component of vehicular pollution [15].

Tractor-trailers and delivery trucks, which make up only about 4% of all vehicles on U.S. roads, are responsible for approximately 50% of nitrogen oxide emissions, nearly 60% of fine particulate emissions, and about 7% of all greenhouse gas emissions in the country [16]. Particulate matter, due to its microscopic size, can infiltrate the human body, affecting the lungs, heart, kidneys, and even entering the bloodstream through the skin. Exposure to these foreign particles can lead to a range of health issues, including respiratory and cardiovascular diseases, and in extreme cases, death. It is estimated that particulate matter and ozone layer depletion will contribute to around 18,000 deaths annually by 2025, with projections indicating a more than 25% increase in these numbers by 2030 [17].

The impact of delivery vehicles on public health and the environment is undeniable. Fortunately, there is growing evidence that a transition away from diesel-powered vehicles is already underway. Electric vehicles (EVs) could offer the much-needed solution to reduce emissions and mitigate the adverse effects of urban pollution.

4.3 Emergence of EV as the Alternative

Electric vehicles (EVs) are rapidly emerging as the preferred option across a wide range of applications. The organized last-mile delivery sector, in particular, has become a key driver of large-scale EV adoption [18]. What was once perceived as a luxury or a futuristic concept is now increasingly seen as a pragmatic, sensible, and desirable choice for businesses, especially in the last-mile delivery segment. By 2025, it is projected that nearly one-third of EV sales will come from the organized last-mile delivery sector, compared to just one-tenth of overall internal combustion engine (ICE) vehicle sales [19].

4.3.1 Advantages of Using EV

Electric vehicles (EVs) offer numerous advantages that make them particularly well-suited for last-mile delivery applications, extending beyond their environmental benefits. EVs generate significant financial savings, primarily due to their lower overall cost of ownership. Over the long term, the total cost of ownership of an EV surpasses that of internal combustion engine (ICE) vehicles, making them a more economical choice for last-mile delivery operations [18].

The willingness to adopt EVs is increasing, and environmental awareness is not the sole driver behind this shift. A key factor is the substantial cost savings derived from the lower Total Cost of Ownership (TCO) of EVs compared to ICE vehicles. Transitioning to EVs for last-mile delivery brings notable benefits in terms of economics, environmental impact, and operational efficiency. Fuel and maintenance costs are significantly reduced, emissions from fossil fuel combustion are completely eliminated, and the carbon footprint of enterprises is considerably reduced. This shift enhances company reputation, positioning businesses as environmentally conscious. Furthermore, EVs contribute to increased safety, reduced traffic congestion, and quieter, less disruptive deliveries.

Low Cost of Ownership: In many countries, vehicle owners can benefit from subsidies when purchasing electric vehicles [20]. According to the U.S. Department of Energy, conventional ICE delivery vans cost an average of 40 cents per mile to operate, compared to just 5 cents per mile for EVs, representing an 80% reduction in fuel costs [21]. In some cases, fuel costs for EVs can even be reduced to zero. Maintenance costs for EVs are also lower, typically around Rs 3,000 per year. Over time, EVs prove to be a more economical choice, with the added benefit of a strong resale value. For example, over a three-year period, an electric two-wheeler (EV 2W) can be up to 30% cheaper than its ICE counterpart. Incentives such as EV adoption mandates and subsidies further promote the adoption of EVs [19].

Lower Maintenance Charges: Unlike petrol and diesel vehicles, EVs have fewer moving parts, which results in less wear and tear and significantly lower maintenance requirements. A study by the Rocky Mountain Institute found that maintenance costs for electric delivery vans averaged just 3 cents per mile, compared to around 10 cents per mile for their fossil fuel counterparts. This translates to potential savings of nearly 70% for companies [21].

Significant Cut Down in Emission of Greenhouse Gases (GHG): Diesel-powered delivery vehicles are a major contributor to urban pollution, exacerbating environmental concerns and global warming. According to the Union of Concerned Scientists, EVs can reduce greenhouse gas emissions by up to 80% compared to ICE vehicles. For electric last-mile delivery vehicles, carbon emissions are reduced by at least 55% compared to traditional diesel delivery vans [22]. This reduction in vehicular emissions aligns with global efforts to combat climate change.

Sustainability Entices Consumers: Today's consumers are increasingly aware of environmental issues and the need for sustainability. A Nielsen study found that 66% of customers are more likely to purchase products from businesses committed to sustainability. Adopting EVs for last-mile delivery operations sends a clear message that a company is dedicated to environmentally responsible practices [21].

Enhanced Productivity: The elimination of refueling requirements for ICE vehicles can reduce labor costs by up to 30%, according to a study by chargedfleet.com. This reduction in time spent refueling leads to faster delivery times and improved efficiency [21]. Additionally, because EVs consume less fuel, they can directly reduce logistics costs, further enhancing productivity [23].

Safe and Silent Deliveries: Electric vehicles are 30% less likely to be involved in accidents compared to ICE vehicles, as reported by the American Lung Association. Furthermore, electric delivery vans generate less noise when operating, reducing noise pollution during deliveries. This is especially beneficial in residential urban areas, where quieter vehicles cause minimal disruption

compared to gasoline-powered vans [21].

In summary, the adoption of EVs in last-mile delivery offers substantial benefits across multiple dimensions, including lower costs, reduced emissions, enhanced safety, and improved consumer perception. As businesses increasingly recognize these advantages, the transition to electric vehicles in last-mile delivery is set to accelerate, contributing to more sustainable and efficient urban logistics.

4.3.2 Disadvantages of Using EVs

While the adoption of electric vehicles (EVs) for last-mile delivery offers clear advantages, it is important to recognize that several obstacles hinder their widespread implementation. The transition is not as straightforward as it may initially seem.

High Upfront Expenses: One of the primary challenges with EVs is their high upfront cost. The purchase price of electric vehicles is typically higher than that of their internal combustion engine (ICE) counterparts, primarily due to the expensive lithium-ion batteries used in EVs. Lithium is a rare earth material, making the batteries costly to produce [24]. As a result, EVs tend to be more expensive, and buyers often gravitate toward cheaper ICE vehicles. While the total cost of ownership of an EV may be lower over time, the initial purchase price remains a significant barrier for many. However, as technology progresses, EV prices are gradually decreasing, making them more affordable in the long run [20].

Inadequate Charging Infrastructure: EVs rely on batteries for power, and these batteries require charging. Unfortunately, the availability of charging infrastructure is often inconsistent [24]. In emerging market economies, public charging stations are scarce, with most charging options being private (e.g., home charging). This lack of infrastructure is a major barrier to EV adoption [25]. Given that EVs are relatively new in these markets, few charging stations have been established, and the existing options are insufficient to meet the demand, especially if EVs are to be widely used in delivery logistics. Logistics companies relying on EVs for long-distance travel must plan carefully to avoid difficulties in finding accessible charging stations, which can often become a major inconvenience [20].

Time Consuming: Unlike ICE vehicles, which can be refueled in a matter of minutes, it typically takes about 8 hours to fully charge a standard electric car using a 7kW charging point [26]. Charging an EV, therefore, takes significantly longer than refueling a conventional vehicle, with the duration varying depending on the battery size. Larger vehicles, such as delivery trucks and vans, have bigger batteries, meaning they will take even longer to charge. While an EV can travel 80 to 120 km on a full charge before requiring a recharge, the time needed to refuel can be a major drawback in last-mile delivery, where speed is critical.

Model Constraints: The EV market still offers a relatively limited range of vehicle models, especially in the case of three-wheeled cargo vehicles used for last-mile delivery. The current selection of electric three-wheelers is narrow, both in terms of aesthetics and customization options, which forces many customers to make compromises [20]. However, technological advancements are steadily expanding the range of available models, and as the market matures, more options are expected to emerge. Despite the limited choices today, consumers are increasingly turning to sustainable alternatives, and the variety of EV models is likely to grow rapidly in the near future.

Range Anxiety: Range anxiety, or the fear of running out of battery before reaching a destination, is a significant concern for many EV owners. Compared to traditional ICE vehicles, electric vehicles typically have a shorter driving range due to limitations in battery capacity and the availability of charging infrastructure [27]. While electric cars are suitable for short-distance trips, they may not be practical for long-distance travel or extended use due to their limited range. On average, EVs offer a driving range of 80 to 120 km, which is sufficient for last-mile deliveries within smaller areas. However, for longer distances, especially in interstate deliveries, EVs are less practical, compounded by the lack of charging stations along longer routes [20].

Maintenance, Repair & Depreciation: EVs typically have fewer moving parts than ICE vehicles, which can make them easier and cheaper to maintain. However, components such as batteries, which require replacement after a certain period, are expensive. Additionally, EVs tend to depreciate more quickly than ICE vehicles due to the rapid evolution of EV technology, which leads to faster obsolescence of older models. As a result, older EVs may have significantly reduced resale value, making them less attractive in the used vehicle market [24].

5. Discussion

For city dwellers, convenience and comfort often take precedence, especially when it comes to shopping. Environmental considerations tend to take a backseat when easy and time-saving e-commerce solutions are available as alternatives to conventional purchasing methods. During the COVID-19 pandemic, online shopping became a necessity as consumers were confined to their homes to avoid physical contact. As a result, e-commerce transactions saw explosive growth, further driving the global demand for last-mile delivery services.

To adapt to this "new normal," last-mile delivery companies have increasingly turned to Electric Vehicles (EVs) and other innovative technologies. The performance of EVs has continuously improved, making them an attractive alternative to diesel, petrol, and CNG-powered delivery vehicles. E-commerce, which was already on the rise, received a significant boost from the pandemic, accelerating the shift to online shopping and intensifying the demand for last-mile logistical support services. This surge in demand for last-mile delivery has, in turn, increased the need for EVs, accompanied by continuous innovations, including improvements in battery technology and faster charging solutions. These advancements have focused on enhancing sustainability while minimizing maintenance requirements, thus making the logistics infrastructure more efficient and cost-effective. As this trend continues, EVs are expected to become even more economically viable, further popularizing their use in commercial applications [29]. The landscape of last-mile logistics is undergoing a paradigm shift. However, widespread adoption of EVs will require significant investment in both physical and financial infrastructure.

On one hand, there is a clear need for implementation; on the other, there are practical challenges. Environmental pollution, especially from diesel-powered delivery vehicles, remains a significant concern. Immediate action is needed. While there is evident intent to transition to cleaner alternatives, as shown by the rising number of EVs being deployed in commercial logistics—particularly in last-mile delivery—adoption rates remain low. A key barrier to wider adoption is the insufficient and fragmented growth of charging infrastructure. The lack of a well-developed EV ecosystem acts as a significant deterrent. Inconveniences related to charging, as well as concerns about range anxiety, are major factors that may discourage delivery companies from integrating EVs into their fleets. Despite efforts to reduce the number of internal combustion engine vehicles, progress has been slow, which contradicts the pollution control targets and greenhouse gas reduction mandates adopted by many countries.

However, encouraging government policies promoting the development of the EV ecosystem, along with subsidies for purchasing EVs, have spurred growth in the market. In addition, escalating environmental concerns have further fueled demand. The global market for electric vehicles is projected to grow at a compound annual growth rate (CAGR) of 21.20%, reaching US$ 1,657.10 billion by 2027 [23]. As discussed earlier, the use of EVs offers clear benefits for many delivery businesses, particularly in last-mile operations, where the limited range of travel makes them a suitable option. While challenges related to design, battery life, and range may exist, continuous innovations in EV technology, including the development of batteries offering improved mileage, are addressing these issues [20]. Although EVs have been around for some time, their efficiency and sustainability have only recently garnered significant attention, particularly from organizations involved in last-mile deliveries.

6. Recommendations

Environmental pollution is a growing concern, exacerbated by the widespread use of internal combustion engine (ICE) vehicles. The increased reliance on lower-grade ICE vehicles for last-mile delivery, driven by the exponential growth of online retail, has contributed significantly to this issue.

Creating a Conducive Ecosystem: While the demand for online retail is unlikely to decrease in the near future, it is possible to develop an ecosystem that fosters the growth and faster adoption of electric vehicles (EVs) for delivering goods to consumers. For the EV ecosystem to thrive, it is essential to understand consumer needs and the evolving trends in the market. This understanding will enable the development of strategies that align with these demands. Key elements in creating a conducive environment for EV adoption include the construction of charging stations at regular intervals, the installation of more charging points on roads, and the development of battery swapping stations.

Local & National Coordination and Robust Public Policies: In line with the U.S. government's

objectives, by 2030, at least 30% of all new trucks and buses sold in the country will be required to be zero-emission vehicles. This initiative aims to position the U.S. for a near-total transition away from ICE vehicles—particularly diesel-powered vehicles—by 2040, which would prevent the emission of nearly 190 million tons of greenhouse gases annually by that year. By 2050, this transition could prevent 580 million tons of GHG emissions. To achieve these ambitious goals, strong public policies and robust coordination at the national, state, and local levels are crucial.

Building Awareness: At the individual level, fleet owners and manufacturers must commit to adopting zero-emission vehicles. Consumers, too, should consider choosing vendors who use green vehicles for last-mile delivery. E-commerce logistics centers around delivering superior customer satisfaction, and green delivery options can significantly enhance this satisfaction. This focus on sustainability can serve as a key differentiator in a highly competitive market. Therefore, raising awareness at both the business and consumer levels is essential. Informing community leaders, policymakers, and corporate executives about the harmful effects of diesel pollution is an important step toward ensuring the widespread adoption of green and clean delivery vehicles.

Use of Hybrid Vehicles: Electric vehicles (EVs) are powered by batteries that store the energy required to run the vehicle. Larger batteries, by virtue of their size, can store more energy and thus offer a greater driving range. To address the issue of range anxiety, one option is to increase battery size. Alternatively, hybrid vehicles can offer a solution. Plug-in hybrid electric vehicles (PHEVs) have smaller batteries compared to fully electric models, but they provide the flexibility of switching to an alternative fuel system when the battery runs out. For example, PHEVs can typically travel up to 40 miles on electric power alone, while fully electric vehicles from brands like Lucid and Tesla can exceed 400 miles on a single charge [26]. This hybrid approach eliminates range anxiety by providing a backup power source.

Use of AI-driven Drone Technology: AI-driven drone technology holds significant potential for last-mile delivery. Recent advancements in drone technology enable faster same-day deliveries, offering a disruptive innovation that not only enhances delivery efficiency but also contributes to sustainability efforts by reducing carbon emissions [30].

7. Conclusion

Urban consumers today prioritize the convenience, comfort, and time-saving aspects of e-commerce over traditional shopping methods. The COVID-19 pandemic further amplified this trend, resulting in a significant increase in the number of ICE vehicles on city streets to meet the growing demand for home deliveries. This has posed a challenge for city authorities, who must balance the needs and expectations of consumers with the need to reduce the negative impacts of urban freight transport, such as air and noise pollution and safety risks—a key element of ensuring social sustainability in cities.

Electric vehicles (EVs) emerge as a preferable alternative to ICE vehicles, particularly electric vans, as they reduce the environmental impact of urban freight transport. EVs produce lower air pollution, effectively reducing the transportation footprint through local emissions reductions.

This article demonstrates that the shift to EVs for last-mile delivery offers significant financial, environmental, and operational benefits. EVs save on fuel and maintenance costs, reduce emissions, and enhance business reputations. They also improve safety, reduce traffic congestion, and provide quieter deliveries. Widespread adoption of EVs is crucial for reshaping urban logistics, with the advantages clearly evident in the reduction of air and noise pollution in cities. With continued advancements in battery technology, EVs are becoming increasingly viable for commercial use, offering improved range and performance.

References

[1] A. Mosby, "How Many People Shop Online In 2024 (Future Predictions)," 25 Dec 2023. [Online]. Available: https://www.yaguara.co/how-many-people-shop-online/. [Accessed 30 Jun 2024].

[2] UNCTAD, "Global e-commerce jumps to $26.7 trillion, COVID-19 boosts online sales," 03 May 2021. [Online]. Available: https://unctad.org/news/global-e-commerce-jumps-267-trillion-covid-19-boosts-online-sales. [Accessed 29 Jun 2024].

[3] Digital Commerce 360, "Global online sales reach nearly $4.29 trillion in 2020," 26 Apr 2021. [Online]. Available: https://www.digitalcommerce360.com/article/global-ecommerce-

sales/#:~:text=Consumers%20worldwide%20spent%20nearly%20%244.29,from%2017.9%25%20growth%20in%202019.. [Accessed 29 A 2024].

[4] TVS Supply Chain Solutions, "The Impact of E-commerce on Transportation and Warehousing Strategies," 28 Sep 2023. [Online]. Available: https://www.tvsscs.com/the-impact-of-e-commerce-on-transportation-and-warehousing-strategies/. [Accessed 30 Jun 2024].

[5] M. Shaikh, "E-commerce by The Numbers: 40+ Eye-Opening Ecommerce Stats You Need to Know in 2024: SMSCountry," 2024. [Online]. Available: https://www.smscountry.com/blog/ecommerce-statistics/#:~:text=By%20the%20end%20of%202024,to%202.77%20billion%20by%202025.. [Accessed 30 Jun 2024].

[6] Aaj Enterprises, "Advantages of Door-to-Door Delivery for E-commerce Businesses," 03 Apr 2023. [Online]. Available: https://www.aajenterprises.com/advantages-of-door-to-door-delivery-for-e-commerce-businesses/. [Accessed 30 Jun 2024].

[7] World Economic Forum, "The Future of the Last-Mile Ecosystem," World Economic Forum, Geneva, Switzerland, 2020.

[8] InsightAce Analytic, "Global Last Mile Delivery Market Research Report," InsightAce Analytic Pvt. Ltd., 2023.

[9] Fact.MR, "Global autonomous last mile delivery market to grow from $17.45 billion in 2024 to $106.27 billion by 2034, with a projected 19.7% CAGR.," Fact.MR, Rockville, MD, United States, 2024.

[10] J. Allen, M. Piecyk, M. Piotrowska, F. N. Mcleod, T. Cherrett, K. Ghali, T. Nguyen, T. Bektas, O. Bates, A. Friday, S. Wise and M. Austwick, "Understanding the impact of e-commerce on last-mile light goods vehicle activity in urban areas: The case of London," Transportation Research Part D Transport and Environment 61, vol. 61, 2017.

[11] World Economic Forum, "Online shopping is polluting the planet - but it's not too late," 10 Jan 2020. [Online]. Available: https://www.weforum.org/agenda/2020/01/carbon-emissions-online-shopping-solutions/. [Accessed 02 Jul 2024].

[12] M. JOSELOW and E. NEWS, "Delivery Vehicles Increasingly Choke Cities with Pollution," Scientific American, 11 Jan 2020.

[13] CURBHUB, "How E-Commerce Growth and Delivery Vehicles are Impacting Cities," 2023. [Online]. Available: https://www.curbhub.io/delivery-vehicles-impact-on-cities/. [Accessed 02 Jul 2024].

[14] EPA, "Final Standards to Reduce Greenhouse Gas Emissions from Heavy-Duty Vehicles for Model Year 2027 and Beyond," 18 Apr 2024. [Online]. Available: https://www.epa.gov/system/files/documents/2024-04/420f24018.pdf. [Accessed 02 Jul 2024].

[15] Environment America, "Electrify UPS Group Sign On Letter," Environment America, Houston, Texas, 2022.

[16] T. O'Connor, "100% zero-emissions trucks. How close are we?: Environmental Defense Fund," 16 Sep 2020. [Online]. Available: https://www.edf.org/blog/2020/09/16/100-zero-emissions-trucks-how-close-are-we. [Accessed 01 Jul 2024].

[17] H. Sinnamon, "Accelerating to 100% Clean: Zero Emitting Vehicles Save Lives, Advance Justice, Create Jobs," Environmental Defense Fund (EDF), 2020.

[18] V. Janakiraman, N. Sankar, A. Khandelia and A. Tiwari, "Electric Vehicles: Future of Last-Mile Deliveries in India," BCG (Boston Consulting Group), 2023.

[19] ET Auto, "EVs –The future of last mile deliveries," 21 Dec 2022. [Online]. Available: https://auto.economictimes.indiatimes.com/news/industry/evs-the-future-of-last-mile-deliveries/96364125. [Accessed 04 Jun 2024].

[20] Turno Expert, "Electric Three-Wheeler for Last-Mile Delivery: Pros and Cons," 13 Apr 2023. [Online]. Available: https://www.turno.club/articles/electric-three-wheeler-for-last-mile-delivery. [Accessed 04 Jul 2024].

[21] Wize-EV, "The Advantages of EV for Last-Mile Delivery," 25 Sep 2023. [Online]. Available: https://wize-

ev.com/blog/tpost/nd20jm8mm1-the-advantages-of-ev-for-last-mile-deliv#:~:text=Conclusion,traffic%2C%20and%20make%20quieter%20deliveries. [Accessed 06 Jul 2024].

[22] ePowerTrucks, "The Impact Of Using An Electric Last Mile Delivery Vehicle," 24 Sep 2021. [Online]. Available: https://www.epowertrucks.co.uk/electric-last-mile-delivery-vehicle-impact/. [Accessed 07 Jul 2024].

[23] TechSci Research, "The Thriving Market for Electric Vehicles in Last Mile Delivery: Market Research Blog," 13 Feb 2023. [Online]. Available: https://blog.marketresearch.com/the-thriving-market-for-electric-vehicles-in-last-mile-delivery#:~:text=The%20main%20advantages%20of%20using,EVs%20can%20reduce%20operational%20expenses.. [Accessed 04 Jul 2024].

[24] B. Paulozzi, "Electrifying Last Mile Delivery: Risk Sgrategies," 21 Sep 2023. [Online]. Available: https://www.risk-strategies.com/blog/last-mile-delivery-electric-vehicles. [Accessed 06 Jul 2024].

[25] A. Marti, "It's not just cars driving the EV revolution in emerging markets: Schroder Global," 27 Mar 2023. [Online]. Available: https://www.schroders.com/en-us/us/institutional/insights/its-not-just-cars-driving-the-ev-revolution-in-emerging-markets/#:~:text=The%20lack%20of%20available%20public,made%20available%20by%20an%20employer.. [Accessed 04 Jul 2024].

[26] W. Clarke, "How Long Does It Take to Charge an Electric Car?: U.S. News," 30 Jan 2024. [Online]. Available: https://www.google.co.in/search?q=ev+charging+is+time+consuming&rlz=1C2YTUH_enIN1063IN1063&sca_esv=ec0ee542ba2d920f&sxsrf=ADLYWIL9UpQtF6EqnaNmfHGIkrLKcRwgQw%3A1720357973789&source=hp&ei=VZSKZtGjLcni2roPjs282AY&iflsig=AL9hbdgAAAAAZoqiZfMGJnyl1wY5YNX3oLGelV. [Accessed 04 Jul 2024].

[27] S. Iwan, M. Nürnberg, M. Jedliński and K. Kijewsk, "Efficiency of light electric vehicles in last mile deliveries – Szczecin case study," Sustainable Cities and Society, Vols. 74, November 2021, 103167, pp. 1-10, 2021.

[28] A. Serohi, "Importance of Battery Recycling and Swapping: The Next Inevitable Step in Electric Vehicle Supply Chain," Int. J Sup. Chain. Mgt, vol. 10, no. 1, pp. 1-20, 2021.

[29] ALTIGREEN, "How Is The Last Mile EV Adoption Scenario In India And Globally," 2023. [Online]. Available: https://www.altigreen.com/blog-3/how-is-the-last-mile-ev-adoption-scenario-in-india-and-globally. [Accessed 04 Jun 2024].

[30] A. Kumar and S. Michu, "Drones Take Flight in Last-Mile Delivery Efficiency. Cio.inc," 20 Jun 2024. [Online]. Available: https://www.cio.inc/drones-take-flight-in-last-mile-delivery-efficiency-a-25572#:~:text=Advancements%20in%20drone%20technology%20are,efforts%20by%20reducing%20carbon%20emissions.. [Accessed 04 Jul 2024]