THE STATE OF ZERO EMISSION DELIVERY IN THE UNITED STATES

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Published May 2025

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EXECUTIVE SUMMARY

We have seen major changes in the last few years as cities and companies in the United States transition to more environmentally sustainable urban delivery. But progress still remains piecemeal and slow. In both policy and practice on city streets, Europe and parts of Asia are far ahead of the U.S. in advancing electrification, shifting away from traditional trucks to smaller forms like e-bikes, and managing city space to induce or support zero emission delivery (ZED).

This paper captures the state of policy and practice of zero emission delivery in the U.S. as of January 2025. It offers a baseline for future work and surfaces levers U.S. cities can consider using to advance ZED. In this report, researchers from the Urban Freight Lab at the University of Washington created a policy and practice framework based on their expertise, review and synthesis of academic literature, current technology and private sector achievements. Via the framework, the research team identifies a three-legged stool of approaches needed to achieve or advance zero emission delivery in the United States. **These three vital areas for progress on ZED are: (1) Electrification, (2) Mode Shift and Behavior Change, and (3) Real Estate and Space Management**. For some, these three key building blocks and the myriad elements discussed in this report may not have been linked as levers to catalyze ZED.

The report is divided into three sections, one for each of the key areas above. Each area has an overview of the current state of practice and associated trends, followed by both public sector-led and private-sector-led examples of the approach under discussion. All examples focus on real-world implementation (both domestic and international), showcasing ZED and/or providing a realistic pathway to advance ZED. And all examples focus a lens squarely on cities.

In the process of compiling this summary of the state of practice of ZED, the research team synthesized key takeaways for cities to consider in Electrification, Mode Shift and Behavior Change, and Real Estate and Space Management.

Key Takeaways: **Electrification – Understand and Incentivize**

1. Cities should understand the current (and emerging) challenges for delivery fleet electrification, current market conditions and vehicle offerings, and emerging models of public-private collaboration in order to design informed policy and create additional incentives to support the electrification of mixed delivery fleets.

2. Despite the legal challenges around regulating vehicle use by fuel type in the U.S., cities *can* adopt initiatives and policies to advance EV adoption in the delivery sector.
3. Businesses are acting on corporate climate goals to invest in EVs and charging infrastructure, with start-ups and new lines of business stepping in to provide these assets and services. Despite progress, demand remains higher than supply for these vehicles, and the cost and time to install charging infrastructure remain prohibitive.

Key Takeaways: **Mode Shift and Behavior Change – Collaborate with Industry**

1. Smaller, electric vehicles as well as operational and consumer-focused shifts towards consolidated pick-ups can provide additional avenues for cities to achieve zero emission deliveries.
2. E-bike use is growing in U.S. metro areas, especially for food delivery. City-run pilots have emerged, providing subsidies, space, and services to support e-bike delivery.
3. U.S.-based companies are acting even without government zero-emission mandates to translate into the U.S.—at a smaller scale—than what is in Europe. Despite U.S. companies having led a decade of experimentation in zero-emission delivery modes, no clear path to scale has emerged for urban goods deliveries. Cities working toward zero-emission delivery face decisions about the role they will play with the private sector.

Key Takeaways: **Real Estate and Space Management – Innovation is Key**

1. Physical space is needed to enable the transition to zero emission delivery which may require cities to rethink approaches to policy and partnerships in order to unlock this vital piece of the puzzle.
2. Cities need space not just for vehicles and charging, but for loading and unloading, too. Cities can use the tools they already have to regulate public space in support of ZED transition.
3. Businesses in the urban freight ecosystem increasingly understand the need to secure and invest in spaces that enable them to roll out new technologies and services. As demand for last-mile-related real estate grows, so too does the need for innovative and flexible private sector use of space to meet changing demands.

Despite progress, key barriers remain in each of the three legs of the zero emission delivery stool. The primary challenges to ZED adoption include the **cost of innovation**, **lack of space**, and a **piecemeal regulatory environment**. In addition to capital costs,

cities must understand the transition costs associated with integrating any new technology and new operational process. Companies must balance these costs with customer expectations and established operation patterns. Space that is dedicated to supporting goods delivery and logistics is limited in urban environments and incentives for experimentation have not focused on real estate for the logistics sector. Finally, cities lack a clear roadmap that communicates a long-term vision with the private sector about ZED and the fragmented and dynamic regulatory landscape is hard to navigate, especially for companies operating in multiple cities and markets.

One overarching theme that emerges from these examples is the clear need for public-private collaboration and understanding. Cities are hard pressed to design effective public policy to advance ZED if they do not have insights into the complex urban freight ecosystem: the myriad private sector actors involved (from carriers to retailers), the market context and economic conditions in which they operate, and the customers they serve.

The policy and practice framework defined in this report clearly articulates the three key elements needed to progress on ZED. This report should serve as a resource for cities to understand the current urban delivery ecosystem and its shifts toward ZED and highlight the variety of tools, tactics, and market-driven approaches in the public and private sectors that may educate and inspire future actions in U.S. cities.

INTRODUCTION

This report presents an overview on the state of policy and practice for zero emission delivery in the United States as of January 2025.[1] This report is targeted to local governments and authorities but is also intended to be a broadly useful summary of real-world pilots and private sector innovation in this space. It also provides a clear framework for advancing zero emission delivery. The literature scan and examples provided are based on a survey of the literature related to zero emission delivery throughout the world including news articles, academic journals, non-profit and industry group publications, city websites and municipal codes, and the expertise of the Urban Freight Lab team. Synthesizing the content, the research team developed a framework emphasizing three key pathways to achieving zero emission delivery (ZED): Electrification, Mode Shift and Behavior Change, and Real Estate and Space Management. This forms a tripartite approach needed to achieve or advance zero emission delivery in the United States. Critically, this report highlights some elements within this tripartite approach that may well have been overlooked to date.

[1] Given the administration change in January 2025, and the frequency and volume of policy changes occurring at the time of this report's publication- we wish to express that this report is based on the state of practice in January 2025.

To begin, we must define what we mean by "zero emission deliveries" and the "urban delivery ecosystem" for the purpose of this report.

Zero emission deliveries are delivered by modes that emit no harmful tailpipe emissions.

The urban delivery ecosystem includes the broader system in which goods are transported and is comprised of a diverse and heterogeneous group of players including: transportation-related (including carriers, third party logistics companies, and delivery vehicle manufacturers); the various public and private spaces goods travel through (such as warehouses, ports, distribution centers, and roadways and the curb); and the legal/regulatory framework and public policies that influence these movements.

As this report is geared toward city-led actions and outcomes, **we will primarily focus on the "Middle" and "Last Miles" of delivery with some examples and references to the "First Mile."**

Cities and the Last Mile

Cities are major generators and attractors of freight trips. In North America, 80 percent of all goods bought and sold start and end their life cycles in metropolitan areas (1). Though less than 4% of vehicles on global roads are trucks, they are estimated to be responsible for 27% of road transport CO2 emissions (2). In the United States, freight emissions grew five times more than passenger emissions between 1990 and 2021- as a result of increases in freight trucking (3).

The last mile in particular has also changed profoundly in the past decade as more urbanites shop online and request same-day home deliveries. These trips are primarily fulfilled by diesel-powered Internal Combustion Engine (ICE) vehicles—semi-trailers, box

trucks, vans, and pick-up trucks-—picking up goods at warehouses and delivering them to residents and businesses in cities. An increasing tableau of carriers—postal and express parcel delivery companies, instant grocery and meal delivery services, and retailer fulfillment services—compete for limited and often congested street and curb space in cities (4). These delivery vehicles also must increasingly compete for limited city street parking not only with other commercial and service vehicles, but also with private and ride hailing vehicles (5). And as a result, according to one estimate, half of road-based freight emissions occur during the last mile of delivery (6).

Increased urbanization combined with increasing same day or just-in-time deliveries are exacerbating negative externalities in urban areas. Those externalities include things that impact urban quality of life and sustainability, such as congestion; health-damaging air and noise pollution; greenhouse gas (GHG) emissions; and road safety hazards (7). Diesel particulate matter (DPM) from freight vehicles remains significantly linked to asthma onset, exacerbation, and respiratory- and circulatory-related mortality with populations of color accounting for about 75 percent of all PM2.5 exposure (a broader subset of pollutants that includes DPM) in the U.S. (8,9).

That said, it is important to state that last-mile urban freight comprises more than just e-commerce parcel delivery. The urban freight ecosystem is incredibly diverse, comprising fresh goods, parcel delivery, facility and service logistics (janitorial, HVAC, plumber etc.), and waste collection. Urban deliveries include everything from construction to wholesale food and beverage, to facilities and service-related deliveries. However, **this report will focus on general cargo, temperature-controlled cargo, parcels, and facility and service logistics, not diving into waste or construction logistics in detail.**

Framing Zero Emission Delivery Approaches

As a result of the changes in shopping behaviors and a greater awareness of the problems associated with them, U.S. cities are beginning to shift attention towards the urban freight ecosystem and measures to decarbonize the sector. In this report, the researchers at the Urban Freight Lab frame a three-legged stool of approaches to achieve or advance zero emission delivery in the United States via: **(1) Electrification, (2) Mode Shift and Behavior Change, and (3) Real Estate and Space Management**. Within each of these three areas (each with a section in this report) is an overview of the current state of practice and associated trends, followed by both public sector-led and private-sector led examples in that space.

The three approaches around which we chose to frame this report represent vital elements needed to support the transition to zero emission delivery. All three are interrelated. All three may offer surprising elements in this report.

The electrification of commercial delivery vehicles is increasing as more models become available and are deployed on U.S. city streets. Light-duty (LD) commercial EVs are seeing the highest rates of deployment to date in the U.S., but both the medium-duty (MD) and heavy-duty (HD) categories are making strides. Cities are doing things like leveraging their purchasing power to stimulate the market for commercial EV fleets and building public charging infrastructure.

Mode shift includes measures that result in carriers and shippers shifting away from traditional vehicles (whether EV or ICE trucks or vans) to smaller-form, more environmentally sustainable modes. **Behavioral changes** encompass shifts in operational behaviors by one or more of the players in the urban freight ecosystem that support zero emission delivery trips. Cities are doing things like supporting dedicated cargo e-bike parking and offsetting start-up or transition costs of companies or independent workers to move to e-bikes for urban delivery.

Real estate and space management includes levers that empower cities to play a key role repurposing urban space in service of a ZED transition. Those levers include management of curb space, the public right of way (streets and sidewalks), and private real estate. Cities are doing things like reallocating curb space and differentiating pricing of this valuable delivery access point to incentivize ZED.

SETTING THE STAGE FOR ZERO EMISSION DELIVERY

Goods movement in cities is not a new phenomenon and is necessary for life. While parcel delivery is a big focus in mainstream reporting, it is critical to acknowledge that ecommerce comprises only a portion of all urban deliveries in cities (15% of retail sales in 2023 or about 4% of daily shopping trips) (10). The urban logistics ecosystem includes deliveries, distribution, returns, collections and servicing with a wide range of stakeholders involved, each with consumer and business demands to optimize urban logistics (11). Urban deliveries span all sectors from construction and waste management to facility and service logistics to wholesale consumables and on-demand restaurant delivery. Thus, it is critical that cities understand the entire ecosystem when planning for the transition to ZED. Especially when considering that, to date, urban freight is primarily a private undertaking

where public actors are not directly involved outside of a somewhat prescriptive regulatory framework and as managers of the built environment (12).

The Highly Diverse Urban Delivery Ecosystem

While cities tend to focus on the last-mile of the delivery and carriers- those entities making the deliveries themselves (as well as the vehicles), understanding the complex and interrelated delivery ecosystem beyond carriers can help cities best design policies and programs to achieve their zero emission goals.

EXPLAINING THE DELIVERY "MILES" WITHIN URBAN FREIGHT

As this report is geared toward city-led actions and outcomes, we will primarily focus on the "Middle" and "Last" miles of delivery with some examples and references to the "First Mile", see Figure 1.

Figure 1. The "Miles" of Delivery, Urban Freight Lab

First Mile

For the purposes of this report, we will refer to the "First Mile" as the beginning of the delivery journey, and this is typically where goods are collected from producers or manufacturers. For goods and components originating overseas, it typically refers to the first leg from Port to warehouse or assembly facility (e.g. drayage truck movements) and includes regional or long-haul transport.

Middle Mile

We will refer to the "Middle Mile" as transport of goods between the First and Last miles. This typically includes moving from a regional warehouse or hub to smaller distribution centers or transporting goods between regional warehouses of an urban area.

Last Mile

We will refer to the "Last Mile" as the last leg of the delivery journey. This typically includes movement of wholesale goods to a retail establishment or parcels moving from a distribution center to the end consumer. The Last Mile includes the "Final 50" of the delivery:

Last 50 Feet or "Final 50"

We will refer to the "Final 50" as the final part of the "Last Mile." This typically includes the movement of the goods from the vehicle to the final destination and may involve the use of a hand cart or pallet and/or traversing within a high-rise building.

THE DELIVERY PLAYERS

Below, we map key players in the ecosystem. (Notably, the list is not exhaustive, excluding, for example, workers and labor, other types of infrastructure such as utilities and grid management, automakers and vehicle brokers.)

Retailers/Shippers/Producers: Retailers include both brick and mortar stores (grocery stores, big box retailers like Walmart, Target, Best Buy, and smaller, local shops) as well as ecommerce giants like Amazon and multinational producers (like Procter & Gamble, Coca-Cola, Pepsi, or Philips/Siemens) Shippers are typically defined as an entity responsible for transporting goods—an action retailers sometimes manage in-house (with/without operating their own fleet) and sometimes outsource to third party logistics firms.

Establishments/Receivers: This highly heterogeneous group encompasses a wide range from small retailers, construction sites, and international retail chains, to shopping centers and grocery stores and restaurants. Each sector has specific demands regarding delivery time, transport conditions, and pricing but typically expect high quality of service (reliability, flexibility, short transit times) at low prices.

Carriers: Members of this highly diverse group (the most visible cog in the urban freight system as those who physically deliver goods to the end destination) provide transport and distribution services and range from individuals or small family businesses to massive international transport companies hired by producers, shippers or receivers. This category

also includes third-party logistics companies (3PLs), which serve as middlemen between suppliers, manufacturers, retailers and other customer types, and may facilitate storage and movement of goods. 3PLs may offer comprehensive logistics and supply chain management services; manage some or all points in a supply chain; and vary in size, services, and industry specialization (13). Of note, in the HD (and therefore registered) trucking industry more than 90% of trucking companies in the US operate less than ten trucks, and roughly 60% are owner-operators operating a single truck (14). This diversity of carriers in size/scale/type makes it challenging to treat this player as a monolith when governments consider policies to advance ZED.

Real Estate and Space Management: For the purposes of this report, real estate refers to private or publicly held land assets and those who manage these assets. In the government sector, this could be public infrastructure like curbs, streets, and off-street parking garages. In the private sector, this could range from warehouses or vehicle storage lots, to parking garages, to other commercial property like retail locations and shopping malls. (Note: More details on real estate's role in the urban freight ecosystem are explained on page 36 of this report.)

Consumers: Historically, consumers had little interaction with the logistics of their goods before they landed on store shelves. Today's online shoppers actively participate in logistics choices by choosing the delivery method: at home or work, curbside pick-up, collection and delivery point (CDP)/parcel lockers, or delivery via a crowdshipping app (15). For the purpose of this report, we will refer to consumers as the general public who make purchases. "Reverse" or "return" logistics are yet another element of the delivery ecosystem as companies and logistics service providers find ways to satisfy e-commerce consumer demand for return shipments.

Government: Municipalities and local agencies focus on the adoption of targets, regulations, and infrastructure, often balancing promoting both sustainable urban development and economic growth (2). To date, U.S. cities tend to have a fragmented approach to integrated urban freight management and very few US cities have a freight planner on staff (16).

MARKET BEHAVIORS

Traditionally, cities have focused on managing the public realm and regulating aspects of the private realm such as zoning, permitting, etc while the private sector has been left to manage the supply chains that service homes and businesses. But cities must understand and ultimately manage the impacts of a supply chain system that has increasingly shifted

towards on-demand and just-in-time deliveries. Additionally, the increasing shift of consumer demand from retail to home delivery is changing the nature of freight circulating in urban areas (12). For example, in London, traffic volumes from LD vehicles increased by roughly 60 percent between 1993 and 2023, despite decreasing traffic volumes from passenger vehicles and HD vehicles over the same time period (17).

Cost of delivery and implications for change

Transporting goods is not free and requires a combination of overhead costs including assets like vehicles and equipment, maintenance, labor, fuel, and in many cases space to function. The last mile of delivery usually makes up about 50% of distribution costs, making urban logistics a competitive factor for players in that ecosystem (12). Carriers adopt strategies to reduce costs based on the regulatory and operational conditions that exist in a given jurisdiction including but not limited to pricing. However, how goods delivery providers react to pricing will vary across supply chains and be influenced by other actors within and beyond the logistics sector (18). Figure 2 below highlights the possible reactions of carriers upon whom pricing tools are imposed. Carriers might respond with operational behavior changes, such as mode shift or a shift to EVs. But it is also possible that carriers will not change their behaviors. Past experience reacting to fines suggests carriers will sometimes absorb pricing costs into their bottom-line, pass it on to their customers by raising rates, or cutting payroll expenses (e.g., by outsourcing to contractors) (19).

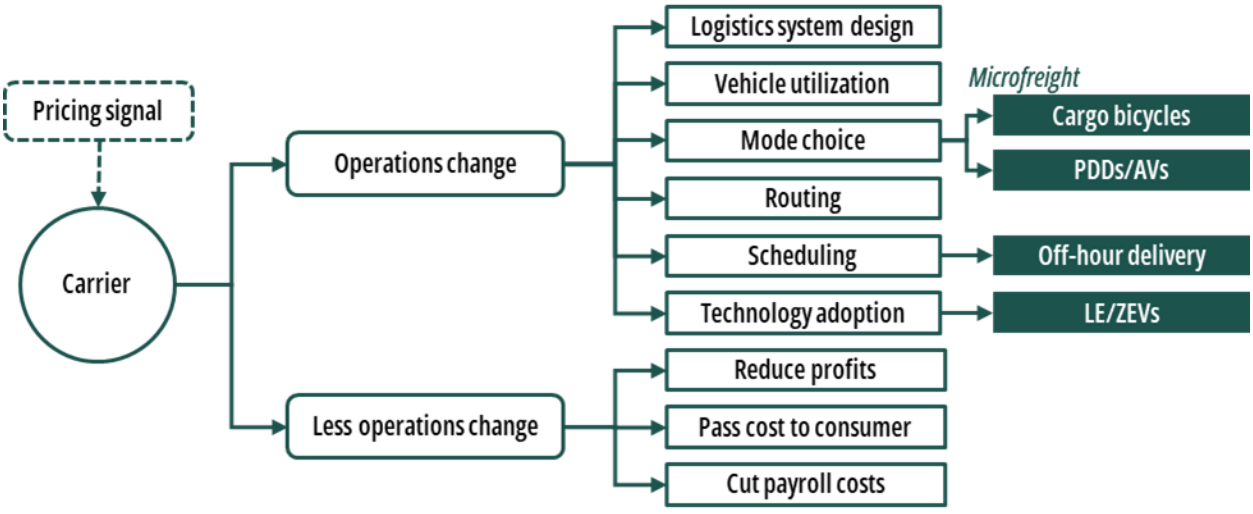


Figure 2. Carrier Responses to Pricing Signals, Urban Freight Lab

ZERO EMISSION VEHICLE AVAILABILITY AND DEPLOYMENT

Often described as the chicken and egg problem, much of the discussion around converting to zero emission delivery fleets highlights the tension between **vehicle**

availability (both options and production-ready models) and the prevalence of **electric vehicle charging infrastructure**. (More details on the levers impacting vehicle electrification will be discussed in the Electrification section on page 18.)

While the market offers an increasing diversity of ZE vehicle options, cost parity of ZE options with comparable ICE options remains a challenge across vehicle classes (and is particularly discrepant at the MD and HD levels). These larger vehicles can be up to three times the cost of a traditional ICE version (20). Not surprisingly, cargo vans make up the largest number of zero-emission deployments on the road in the U.S., much larger than all other vehicle types combined. CALSTART reports some 37,831 ZE cargo vans have been deployed, with 11,900 new vehicles in the first six months of 2024 (21). This is mainly due to the lower upfront costs to acquire these vehicles, the smaller batteries required to power the vehicles, and the number of models available from multiple OEMs. That said, zero-emission vans still make up a small share of *all* cargo vans in service (20).

According to the International Council on Clean Transportation, registrations of new zero-emission heavy duty vehicles (ZE-HDVs) in the U.S. rose from 200 in 2021 to 1,600 in 2023 (22). The share of ZE-HDVs in all HDV registrations rose from less than 0.10% in 2021 to 0.30% in 2023, but remained low. By way of comparison, in 2023, there were 11,000 new ZE-HDVs sold in the EU and more than 110,000 sold in China (22).

Not represented in the figures above are the growth in ZE microfreight options, including bicycles, personal delivery devices (e.g. delivery robots) and drones. (More detail on these options and their growth and scaling are outlined in the Mode Shift section on page 27.) But for a quick comparison, Amazon has launched micro-mobility hubs to support e-cargo bike operations in more than 20 cities across Europe, including London, Munich and Paris, and expects to double that figure by the end of 2025 (23).

Why the U.S. Lags Europe and Parts of Asia in Zero Emission Delivery

Europe and parts of Asia have logged more progress in ZE delivery than the U.S. to date. As such, this report cites select international examples to illustrate what is possible, but otherwise focuses on strategies already underway in the U.S. and/or transferable for the U.S. context. That said, key governance, legal/regulatory, and political differences between the U.S. and Europe present U.S. cities with specific challenges and opportunities in trying to regulate toward ZED outcomes.

One key difference is the physical layout of the cities themselves: Europe tends to have denser and older cities, creating infrastructure pressures that have driven smaller delivery vehicle form factors even before ZE vehicles became available. Another key difference is

Europe's top-down regulatory approach, with aggressive climate reduction targets, laws around fuel economy, existing road and area pricing schemes, and increasingly, low and zero emission area restrictions. Unlike most U.S. cities, European cities have more consistently included urban logistics in their broader Sustainable Urban Mobility Plans. In 2022, 62 of 107 sampled European cities (58 percent) mentioned urban logistics in those plans and 14 cities (13 percent) had separate Sustainable Urban Logistics Plan (24). In contrast, only 5 cities in the US had separate SULPs or freight plans (25). By incorporating urban logistics and in particular goals around zero emission delivery into plans, this offers predictability for private enterprise, ensuring consistent rules to allow the private sector to adapt and innovate.

Additionally, Europe has modeled the importance of public messaging around their various policies by leaning more heavily into messaging around health and healthy cities when advancing congestion pricing and ZE zones. Such holistic messaging may lower the risk of legal scrutiny by widening the lens of positive benefits beyond just climate and emissions. They place emphasis on existing city goals around traffic reduction, public health and safety, and vibrancy and economic concerns, rather than solely focusing on vehicle emissions (26).

Leaders in many U.S. cities have paid less attention to goods mobility than people's mobility–for myriad reasons. Those include (1) a belief or deference to the private sector as the leaders of freight activity, resulting in minimal government intervention to avoid inhibiting competition; (2) a lack of a single authority with jurisdiction to influence freight at a metropolitan scale; (3) the challenge to understand the freight transport ecosystem when data is hard to collect and guarded by industry; and (4) the challenge to understand the complex freight transport ecosystem involving multiple actors and goods distribution networks (27).

And finally, the existing U.S. legal framework that exists at the federal level creates headwinds to progress on the topic of zero emission delivery. More on that below.

Legal Considerations in the United States

Legally, federal preemptions limit the ability for cities to regulate vehicles by fuel type (16). The Federal government (with the Clean Air Act and Energy Policy and Conservation Act) has assumed authority over emissions standards and preempts or overrides state and local governments from passing laws that regulate the emissions from vehicles. Exceptions are only allowed in jurisdictions where the criteria pollutants exceed federal regulations for more than half the year. This exception lets the state of California set stricter, binding

emissions standards for manufacturers–standards other states are permitted and have adopted (28).

Similarly, the Dormant Commerce Clause of the U.S. Constitution gives the Federal government the authority to regulate commercial activity–such as freight–that crosses state lines. This, in addition to the Federal Aviation Administration Authorization Act, makes cities and states unable to dictate the types of vehicles used by freight companies. In combination, these acts effectively limit cities in the types of direct restrictions they can impose on freight carriers (other than an explicit exception for legal requirements relating to size or weight of vehicles or highway route controls (26).

Despite these legal hurdles, there are still viable pathways for cities to pursue zero emission delivery- they must just do so carefully and in full knowledge of the federal laws (and any other state law that may preempt their efforts). This requires a holistic and strategic approach. Bans or fees on all vehicle traffic (such as pedestrian or walking streets), are less likely to be blocked than those that ban or toll only some vehicles, based on emissions or fuel economy. Cities can provide incentives for using zero- or low-emissions technology as opposed to mandates, as long as the incentives are structured as to not be “so coercive as to indirectly [constitute a] mandate” (28). Incentives might include access to EV charging (on-street or off-street), zero or low emission loading zones, or differentiated pricing for commercial vehicle permits. The Clean Air Act permits “in-use” restrictions for vehicles, such as carpool lanes or restrictions on car use in downtown areas, which can reduce both traffic and emissions (28). Size or weight restrictions on vehicles (which can serve as an imperfect proxy for vehicle emissions) and programs setting truck routes are generally not preempted (28). Finally, cities are able to use their power of procurement to build demand in emerging areas of zero emission technology- an example we dive into later in this report. A city is legally permitted to favor low- or no-emissions technology where it is procuring its own goods or services (28).

ELECTRIFICATION

ELECTRIFICATION

This section will focus on the transition from a traditional ICE delivery van or truck (light, medium, or heavy-duty) to an electric vehicle, which, in addition to vehicles, may include cargo and 2-wheel e-bikes or scooters. It will also include charging infrastructure examples that support this transition.

Electrification in Context

Key Takeaway: Cities should understand the current (and emerging) challenges for delivery fleet electrification, current market conditions and vehicle offerings, and emerging models of public-private collaboration in order to design informed policy and create additional incentives to support the electrification of mixed delivery fleets.

The electrification of vehicles eliminates emissions generated at the tail-pipe of ICE commercial freight fleets. But several challenges currently hamper the rate of transition to zero-emission delivery fleets: (1) a lack of readily available models for electric MD/HD vehicles; (2) the cost of those electric commercial vehicles that *are* available, as well as the cost of charging infrastructure; and, (3) the cost and complexity of ensuring needed electrical grid upgrades to support the charging infrastructure. Overall, electrification faces a chicken and egg problem: Companies do not want to invest in electric vehicles if they do not have sufficient charging capacity and infrastructure installed; however, those installations can take years to complete while vehicles may be available sooner.

To help advance the electrification of delivery fleets, cities must understand who owns these fleet assets (and, therefore, who could benefit from rebates and incentives) as well as the complex and heterogeneous ecosystem of carriers, shippers, and fleet management services. The last-mile delivery space increasingly relies on third-party logistics operators (3PLs) and/or asset-light fleets. More shippers and retailers that traditionally owned and managed fleet assets are moving towards rental or leasing models and/or outsourcing entirely the final leg of delivery to 3PLs. Those 3PLs, in turn, may also rent or lease fleets from brokers like Penske, Ryder, Merchants Fleet, Budget Truck Rental and others.

Charging is the other key factor in the transition to vehicle electrification. Publicly-available facilities are one piece of the charging puzzle for commercial EV fleets; depots are another.

The International Council on Clean Transportation (ICCT) in 2021 estimated that the U.S. will need more than 2 million depot-based chargers by 2050 to meet charging demand (29). Atlas Public Policy also estimates that up to 90% of freight-related charging will occur at depots (30). That said, both the ICCT and Atlas suggest that investment in public charging infrastructure is still needed because more than 90% of trucking companies in the U.S. are owner-operators or are fleets of six trucks or fewer (31). Such small enterprises may not be able to afford to install chargers and/or access depot-based overnight charging.

POLICIES ADVANCING ELECTRIFICATION OF COMMERCIAL DELIVERY FLEETS

Several state and federal policies are helping to shape the adoption of ZEVs in the commercial fleet market. These included increases in federal vehicle emissions standards. Through the U.S. National Blueprint for Transportation Decarbonization (See Appendix, Table 1) and the Global Memorandum of Understanding for Zero Emission Medium- and Heavy-Duty Vehicles, the United States committed to identify ways to promote at least 30% ZE MDHDV sales by 2030, with a goal of 100% by 2040 (32,33). Additionally, the U.S. DOT's National Zero-Emission Freight Corridor Strategy, released in 2024, outlined an all-of-government approach to aligning investments and accelerating sustainable and scalable deployment of reliable ZE-MHDV infrastructure along freight corridors and highways (34). **Of note, with the administration change in early 2025 there remain open questions about what goals and federal funding focus areas may change or are changing; an important factor for state and local governments to understand in the context of planning for zero emission delivery strategies.**

At the state level, a coalition of 15 states plus the District of Columbia, signed a pledge to transition to zero-emission all MD and HD vehicles in their jurisdictions by 2050 (35). California, for its part, has passed two notable policies related to fleets and trucking and maintains unique status to dictate its own emissions policies. (States can choose whether to adopt the federal standards or California's more stringent standards.) A 2020 Advanced Clean Truck (ACT) regulation required that truck manufacturers sell an increasing number of zero-emission/near-zero-emission MD and HD vehicles as a percentage of their overall truck sales, starting as early as vehicle model year 2024 (36). The 2023 Advanced Clean Fleet (ACF) regulation extended the policy's impact on the U.S. commercial fleet directly by requiring MD and HD fleets to phase out ICE by 2045 (36). The ACT was granted an EPA waiver in 2023 to proceed; however, the ACF EPA waiver was under review as of January 2025 and aspects of ACF have been repealed by the California Air Resource Board, CARB, the agency that governs this regulation (37).

FUNDING ELECTRIFICATION OF COMMERCIAL DELIVERY FLEETS

In addition to setting policies with timelines for ZE model availability and shares of MD and HD ZE vehicles comprising fleets, the U.S. has allocated billions to support MD/HD vehicle charging infrastructure. One analysis suggests that private investment in MD/HD charging grew 270 percent in just two years, from 2021 to 2023 with the top private fleets investing in MDHD charging include TerraWatt Infrastructure, Daimler AG, Amazon and Anheuser-Busch (38).

Enacted in 2021 as part of the Infrastructure Investment and Jobs Act (IIJA), the federal government created multiple programs to provide funding for highway and local-access charging stations. The National Electric Vehicle Infrastructure (NEVI) Formula Program sought to accelerate installation of an interconnected nationwide network of public EV charging stations along designated highways and corridors (39). Local municipalities and metropolitan planning commissions were able to compete for $2.5 billion in federal Charging and Fueling Infrastructure (CFI) grants to fund public EV charging infrastructure and other alternative fueling infrastructure projects (40). Both contributed to an increase in charging ports available nationwide.

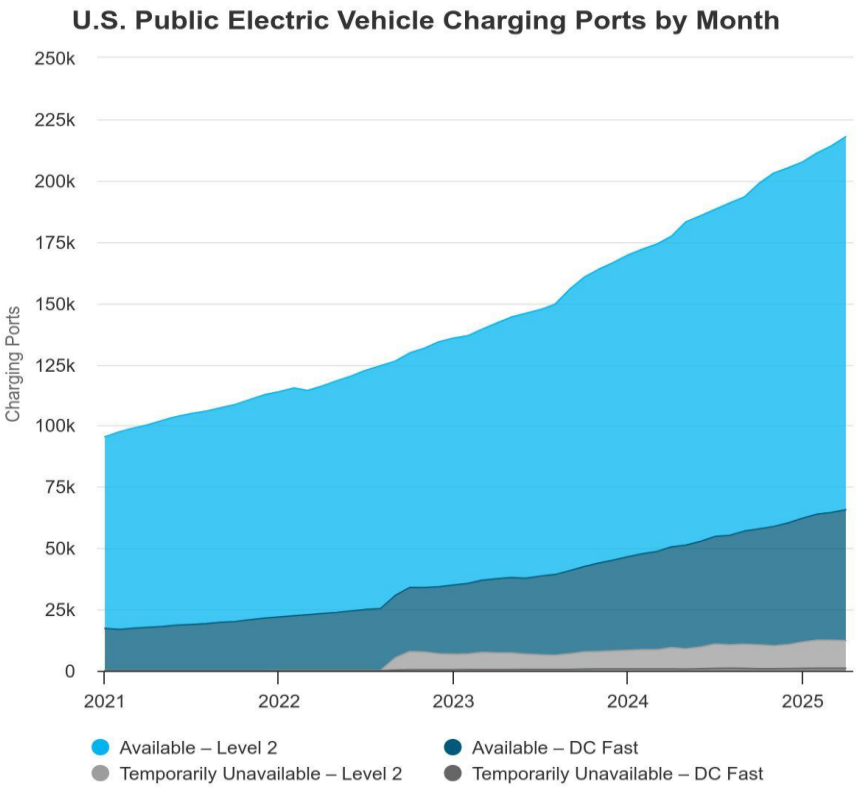


Figure 3. Available Public EV Charging Ports, Joint Office of Energy and Transportation (41)

When it comes to ZE vehicles, both the federal government and many states currently offer rebates and other incentives to promote the purchase of electric vehicles. Federal rebates, for example, target businesses and tax-exempt organizations purchasing new commercial EVs, granting up to $7,500 for vehicles under 14,000 pounds, and up to $40,000 for all others (42).

VEHICLE MANUFACTURER GOALS

As shown in Appendix, Table 3, from CALSTART, many major automakers or original equipment manufacturers (commonly referred to as OEMs) defined a U.S. ZEV or carbon neutrality goal as of December 2023. (This list does not include ZE-only manufacturers , such as Rivian and Nikola, as their targets are inherently ZE.) Manufacturer ZE goals are anticipated to generate increased ZE vehicle availability and production, which in turn, is expected to reduce the cost of new ZE vehicles (20).

As to current vehicle availability, CALSTART in 2024 reported around 160 zero-emission vehicle models (across all vehicle types) in the U.S. are being produced by more than 40 different OEMs. Table 2 in the Appendix shows the distribution of available vehicles used for freight and goods movement by vehicle type and classification (by gross vehicle weight rating) (20).

Below we give examples of electrification advancing efforts in the commercial vehicle and delivery space. We will contrast public-sector led initiatives with private-sector led initiatives to surface the current state of practice in 2024.

Examples: Public Sector Advancing Electrification

Key takeaway: Despite the legal challenges around regulating vehicle use by fuel type in the U.S., cities *can* adopt initiatives and policies to advance EV adoption in the delivery sector.

EXAMPLE #1: PUBLIC SECTOR CAN LEVERAGE PURCHASING POWER TO STIMULATE THE MARKET FOR EV FLEETS

Key takeaway: Cities may not be able to legally dictate the fleet composition of private delivery fleets but they do have influence on private markets via government procurement and purchasing power. Leading by example is important and a place that the public sector has legal authority and control to take action swiftly.

City governments are tapping their procurement power to invest in EVs, directly increasing the number of EVs in circulation and signaling demand across vehicle classes, including—more recently-–larger MD/HD vehicles. The nearly 270 participating public fleet managers

in the Climate Mayors EV Purchasing Collaborative are leveraging their collective buying power to accelerate municipal fleet conversion to EVs and demonstrate market demand (43). The collaborative is a hub for fleet EV transition, providing training, best practices, educational resources, and analysis support. In addition to the Purchasing Collaborative participants, nearly 350 mayors representing 46 states and nearly 60 million Americans have committed to electrifying at least half of their fleets by 2030 and increasing EV infrastructure by 500% by 2035 (44).

EXAMPLE #2: BUILDING PUBLIC CHARGING INFRASTRUCTURE SUPPORTS COMMERCIAL FLEETS

Key Takeaway: While private or depot-based charging is fundamental for most delivery and commercial fleet charging, publicly accessible charging infrastructure must exist to support the overall ecosystem. Opportunity charging and public charging that can be accessed by smaller companies and owner-operators can help to widen accessibility and reduce range anxiety for purchasers.

As noted earlier, while many larger commercial delivery fleets are presumed to charge at a depot or other non-public charging station, public charging can make EV charging more financially accessible for the nation's many smaller fleet operators (and enhances opportunity charging for long-haul EV delivery.) The aforementioned billions in federal funds allocated in recent years have accelerated investment in public charging. Cities that won Charging and Fueling Infrastructure (CFI) grants are investing in making sustainable infrastructure accessible to drivers of electric and alternative fuel vehicles, including in downtown areas and local neighborhoods, particularly in underserved and disadvantaged communities (40). Grantees span states from every region of the country. This newly installed public infrastructure can serve to alleviate range anxiety, by offering peace of mind that adequate charging exists if needed. As of Fall 2024, over 200,000 public charging ports were available nationwide, nearly doubling the available ports in less than three years (45).

In addition to vehicle charging, examples of public charging for e-micromobility are starting to emerge in US cities, demonstrating a nexus between electrification, mode shift, and fire safety. In 2024, the NYC DOT began piloting public battery swapping stations for charging two-wheel electric bicycles and scooters, specifically targeting food delivery workers who use these vehicles (46). The pilot launched in the wake of deadly apartment fires linked to lithium-ion batteries that power the e-bikes and e-scooters—devices typically recharged in delivery workers' apartments. Data show high use of the public charging station among participating delivery workers and substantially lower use of home charging (47).

Public Battery Swapping Stations in NYC, Photo credit: New York City Department of Transportation

EXAMPLE #3: CONGESTION PRICING CAN ADVANCE THE ADOPTION OF EVs

Key Takeaway: This European example illustrates the use of top-down policy levers to induce electric vehicle uptake in cities. While U.S. legislation preempts the introduction of area-based low emission or zero emission zones (L/ZEZs) (eg restricting vehicles from an area based on emission/fuel type), U.S. cities can pursue pricing schemes like congestion pricing and/or tolling that serve to change the cost equation for deliveries in urban areas.

Congestion charges are fees typically levied on vehicles entering an urban or downtown area, intended to reduce congestion and improve safety and mobility. Those fees generally vary by time of day, with higher charges for peak congestion hours, and (for commercial vehicles) by number of axles or weight classes.

Milan adopted congestion charges in 2012 for a low-emission zone, Europe's largest by geographic area. Milan has increasingly layered incentives within the scheme to encourage zero-emission vehicles, initially charging entry fees to all vehicles except motorcycles and mopeds. Eventually, the city added electric, hybrid, bi-fuel, and natural gas vehicles to the no-fee list. Today, the only vehicles exempt from entry fees are electric and hybrid vehicles emitting less than 100g of CO_2/km (48). Additionally, the city incentivizes zero-emission delivery vehicles by granting them special access to the Low Emission Zone (LEZ). While most delivery vehicles are not allowed to enter and load/unload in the LEZ on weekdays from 8:00 and 10:00 AM, electric delivery vehicles *are* allowed to enter the zone during

those hours—and are granted free access to loading zones (49). Overall, researchers found that between 2012 and 2017, Milan's LEZ decreased CO2 emissions by 22% (48).

Map of Congestion Relied Zone in NYC, Photo credit: Metropolitan Transportation Authority (MTA)

In the U.S., NYC became the first city to implement congestion pricing in January 2025. Notably, the city's approach relies on traditional tolling practices by differentiating prices by vehicle class (with trucks paying more than passenger cars and larger trucks paying more than smaller trucks), not emission type (50). How the pricing scheme will impact mode shift and fuel shift (to ZE vehicles) should be studied carefully and compared to changes observed in Europe.

Examples: Private Sector Advancing Electrification

Key takeaway: Businesses are acting on corporate climate goals to invest in EVs and charging infrastructure, with start-ups and new lines of business stepping in to provide these assets and services.

EXAMPLE #1: COMPANIES ARE PURCHASING ELECTRIC VEHICLES OUTRIGHT

Key Takeaway: Private companies are procuring electric vehicles and transitioning fleets and depots to support these new vehicles. Different reasons for the shift drive motivations; some may be taking advantage of 'first-mover' benefits like rebates and incentives and/or early access to vehicle production and electrical grid upgrades for charging.

Some larger companies are investing in EVs and charging infrastructure by buying the assets outright and installing charging systems at their depots and warehouses. Big companies taking this approach include retail giants like PepsiCo and Sysco. Importantly, while the private sector is leading these investments, many still benefit from government incentives and rebates provided at the state and federal levels.

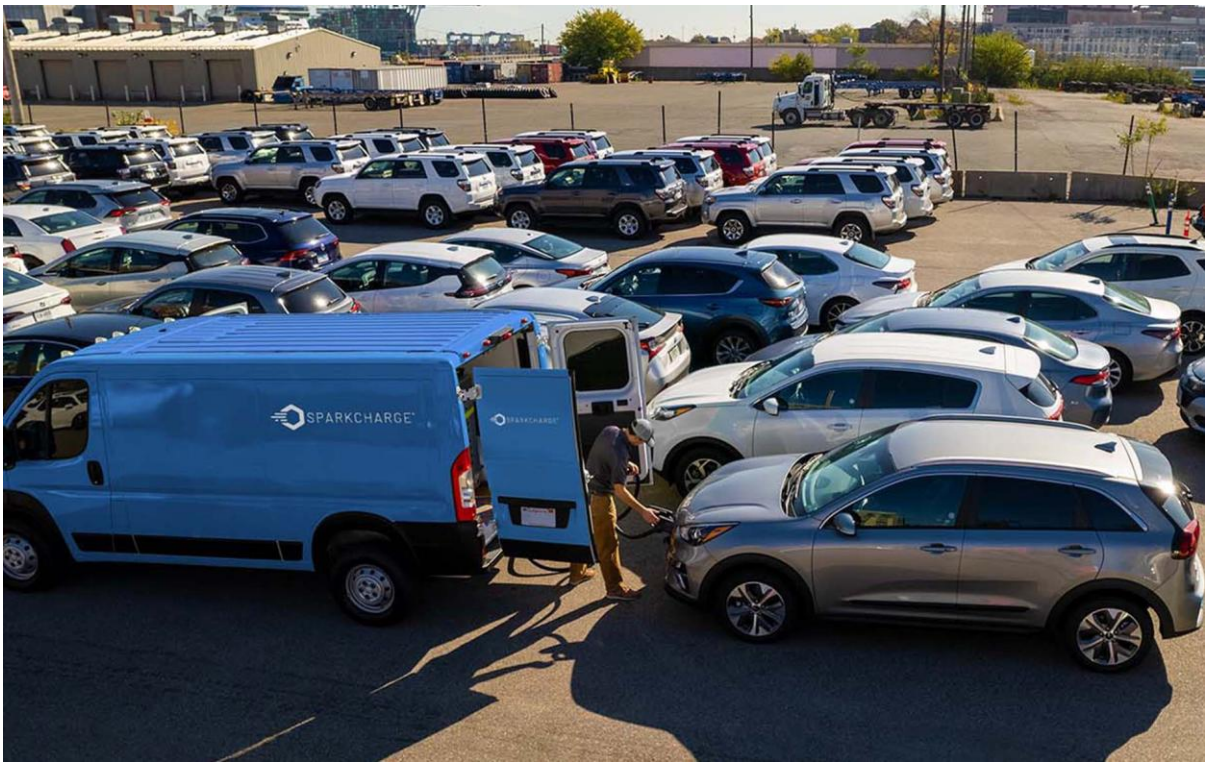
Fleet of Pepsi Tesla Semi Truck Cabs, Photo credit: PepsiCo

PepsiCo is expanding its EV fleet in California, adding 50 Tesla Semis (for 89 total) and 75 Ford E-Transit vans as part of its target of reaching net zero emissions by 2040 (51). The company has installed major charging infrastructure at sites like it's Fresno operation, a 170,000-square-foot manufacturing facility. Grants from the California Air Resources Board, the San Joaquin Valley Air Pollution Control District, and the California Energy Commission support PepsiCo's electric fleet expansion (51).

Wholesale food distributor Sysco in 2024 added ten Freightliner eCascadia electric Semis and announced a plan to deploy some 800 battery-electric tractor-trailer trucks by 2026. At the unveiling of the Tesla Semi in 2017, Sysco announced it had reserved 50 of the e-trucks. Sysco's current EV fleet is reported to number 120 trucks. Sysco leaders have stated a goal of electrifying 35% of the company's US fleet, with an estimated 2,500 electric trucks by 2030 (52).

EXAMPLE #2: CHARGING-AS-A-SERVICE FOR FLEETS

Key Takeaway: Private companies that are making the transition to electric fleets may face challenges to install charging infrastructure- either due to capital constraints or lengthy installation timelines (related to permitting or utility-side grid upgrades). New start-ups are emerging to offer charging-as-a-service (CAAS) that may help to minimize risk for these companies in transition and/or provide a charging service that would otherwise be unavailable (eg small business owners that receive a fully subsidized drayage truck but do not have the means to install associated charging infrastructure).



Mobile EV Charging from SparkCharge, Photo credit: SparkCharge

Charging-as-a-service is being offered to fleet operators as a way to reduce the capital costs required to transition to an electric fleet. Two start-up business models from such service providers are highlighted here. The first, SparkCharge, provides mobile/on-demand

charging services, essentially removing infrastructure installation and lowering maintenance costs for fleets (53). This service could also prove useful for fleets that operate in areas with fewer publicly available chargers as a means to access opportunity charging.

The second, Forum Mobility, provides depot-based charging-as-a-service geared specifically toward HD EVs, with depots at ports and located along routes to common freight destinations. They are making their first installations in California, which makes sense as California has more than 30,000 drayage trucks registered and state policies like ACT and ACF that imposed dates to transition to 100% zero-emission drayage vehicles (54). In 2024 the company started building a charging depot at the Port of Long Beach in California designed to charge 44 trucks simultaneously and with capacity for 200 trucks a day. Companies planning to utilize the depot include Amazon Global Mile, Talon Logistics and Ocean Network Express (North America) / Boxlinks (55). Companies can buy a monthly subscription fee for charging or charging plus access to a HD drayage electric vehicle through a partnership with Climate United (56).

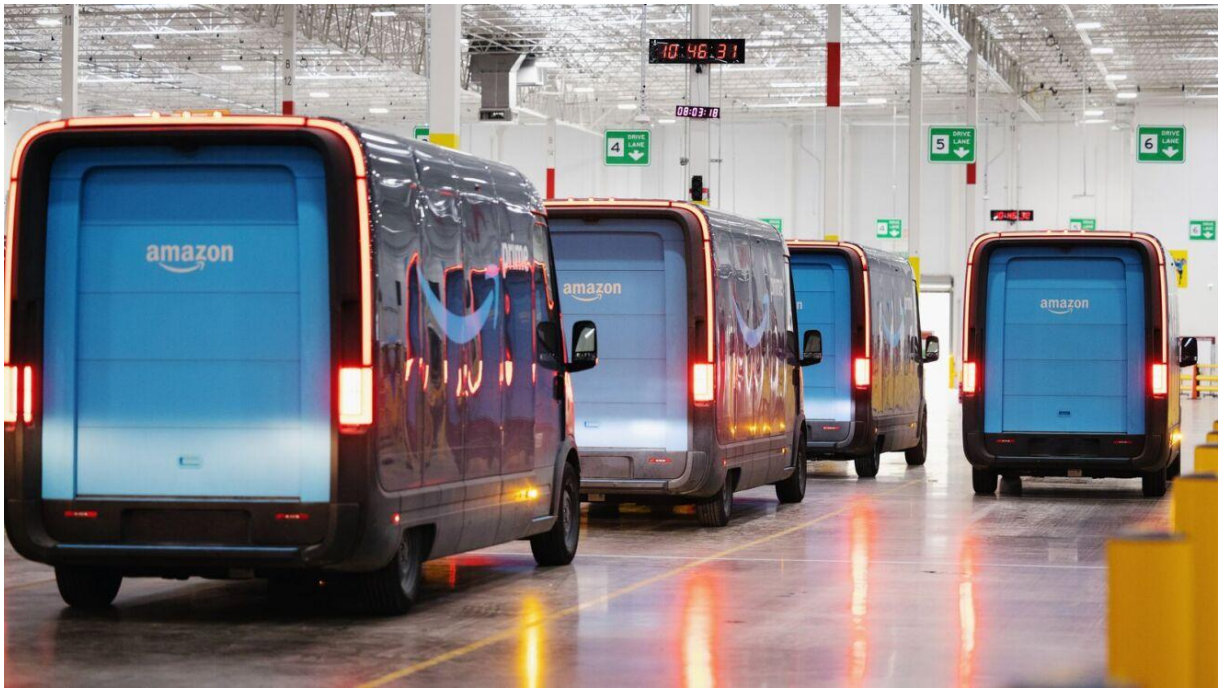
EXAMPLE #3: COMPANIES THAT DO NOT OWN THEIR FLEETS ARE MAKING PROGRESS ON EV GOALS

Key Takeaway: For retailers, shippers and carriers that do not own their fleets, there are still opportunities to influence contractors and independent workers to choose electric options. They can lower the financial barriers to access the vehicles or charging through incentives or via supportive services like preferred access to charging or battery swapping stations, or access to the vehicles themselves via third-party brokers.

As discussed previously, many companies in the delivery and logistics sector do not own their delivery vehicle assets outright. Many factors are at play, such as the use of third-party (3PL) or contracted logistics providers; the use of independent contractors (“gig workers”); and/or the economic decision to simply lease or rent fleet vehicles instead of buying the vehicles outright. But companies do not have to own their assets to advance corporate climate goals around zero-emission deliveries and electrification.

Amazon operates as both a retailer and a shipper and in 2023 reportedly surpassed UPS in delivering more packages to US homes than UPS (UPS is still the world’s largest delivery service provider) (57). Importantly, and in contrast with UPS’ W-2 employee model, Amazon’s complex logistics network includes a significant portion of deliveries performed by over 3,000 contractors (referred to as delivery service partners, DSPs) worldwide (58). Amazon does not own the branded delivery vans these DSPs use to perform Amazon

deliveries, but rather negotiates leasing options and discounts with third-party fleet management companies for DSPs to access these vehicles (59).



Amazon's Rivian Electric Van Fleet, Photo credit: Amazon

As part of Amazon's pledge to become net-zero carbon by 2040, the company has partnered with manufacturer Rivian (in which Amazon is a major investor) to put 100,000 electric delivery vehicles on the road by 2030 (60). Amazon now has more than 20,000 e-delivery vehicles operating across the U.S. and has installed 24,000-plus chargers at more than 150 delivery stations nationwide (60). The DSPs are able to store and charge these leased vehicles at Amazon facilities and use Amazon-funded charging infrastructure. With its vast scale, Amazon considers itself to have the nation's largest EV deployment and "the largest private charging infrastructure in the country." Amazon officials have cited electrical grid capacity and permitting as their biggest challenges in siting the 100-plus sites where charging is needed, requiring a team to coordinate with myriad local power companies (61).

As with Amazon above, IKEA, another global retailer and shipper, does not own its delivery fleets, but rather helps third-party contractors access EVs through leasing companies. They have set ambitious goals specifically around zero-emission delivery to have 100% of all IKEA home deliveries be emission-free by 2025 (62). And, like Amazon, IKEA is building out charging infrastructure at their retail locations that logistics companies can access (63). Additionally, IKEA offers support to its contractors to advise on moving electric and

managing charging needs. While the company has reported progress, doubling the share of zero-emission deliveries to 24.6 percent from fiscal 2022 to fiscal 2023 (and achieving 100% electric deliveries in Shanghai, China), officials suggested that the availability of both EVs and charging infrastructure have hampered progress to date (64).

Uber works exclusively with independent contractors in the U.S. and unlike Amazon and IKEA does not have a retail or real estate footprint. However, Uber has set goals to make all deliveries and rides zero-emission in the U.S. by 2030 and globally by 2040 (65). To support the transition of Uber ride hail and delivery drivers to electric cars and bikes, Uber provides delivery drivers subsidies to buy EVs, discounts for charging subscription services, and, in some cases, funds charging infrastructure.

Uber Drivers Can Access Discounts with Evgo Charging, Photo credit: Uber

For example, in the U.S. Uber drivers who achieve certain status levels within the Uber Pro program can save up to 45% on charging costs at over 1,000 EVgo fast-charging locations across the country or access EV rental or purchasing discounts through Uber partners (66). Uber also committed £5m to install 700 chargers across three London boroughs to accelerate the installation of public charging ports for their drivers (67). And in Taiwan, Uber Eats e-scooter delivery riders can now receive discounts to buy new Gogoro Smartscooters and to use its thousands of battery swapping stations around Taiwan. Uber expects this partnership to help eliminate downtime for delivery drivers to stop and recharge with a goal to double electric trips from 20% to 40% by the end of 2025 (68).

MODE SHIFT / BEHAVIOR CHANGE

MODE SHIFT/BEHAVIOR CHANGE:

In the context of this report, measures that result in carriers/shippers shifting mode away from traditional vehicles (whether EV or ICE trucks or vans) to smaller-form, more environmentally sustainable modes. And/or shifting operational behaviors by one or more of the players (consumers, carriers/shippers, retailers) that result in increased zero-emission delivery trips. These operational behaviors may be triggered by the mode shift itself or by other factors.

Key Takeaway: Smaller, electric vehicles and both operational and consumer-focused shifts towards consolidated pick ups can provide additional choices and methods for carriers and cities to achieve zero emission deliveries.

Current Challenges with Conventional Delivery Fleets in Cities

Conventional ICE trucks predominate the nation's commercial fleet when it comes to delivering goods within cities. From an operational perspective, congestion of roads and curb parking spaces reduce the efficiency of commercial vehicles in delivery in urban areas. Past Urban Freight Lab studies have found that about 80 percent of a delivery driver's time is spent parked on the curb, and most of the delivery time takes place on foot (69). From a safety perspective, heavier vehicles are associated with an increased likelihood of fatality in vehicle accidents. Moreover, 60 percent of vehicle accidents occur in urban areas. Being hit by a 1,000-pound heavier vehicle is associated with a 47 percent increase in the probability of fatality (70).

To be sure, traditional vehicles will continue to play a vital role in the last mile in the foreseeable future. But new technology can enable a more sustainable path to more nimbly distribute goods and services in cities (71).

Mode Shift: Goods Delivery via Cargo E-bikes and Food Delivery via E-bike

U.S. cities are beginning to shift their attention to the delivery sector by advancing mode shifts away from trucks and vans and into e-bikes and cargo e-bikes. Though bikes specially designed for cargo transportation have existed for years, newer electric cargo bikes (cargo e-bikes) allow transport of heavier loads for longer distances while retaining most of the flexibility and agility of a bicycle. The global market outlook for 2 and 3-wheeled electric cargo bikes is estimated to grow by 13.1% compound annual growth rate (CAGR) from 2024 to 2034 (72). Especially in urban areas, cargo e-bikes can offer advantages compared to motorized vehicles. Cargo e-bikes have proven to be faster, able to park closer to their delivery destination, travel on more of the urban infrastructure (able to ride in bike lanes and on pedestrianized roads and pathways such as sidewalks and closed and pedestrianized streets), and in some cases avoid traffic congestion. They are zero-emission, with an estimated total social and environmental cost of 12 percent of that of a diesel van and 14 percent of that of an electric van (71).

However, cargo bikes cannot service all segments of goods delivery. Their payload and carrying volumes are smaller and traditional vehicles can cover more expansive areas and ride on highways and multi-lane roads. Especially in the US, vehicle-centric cities have shaped vehicle-centric logistics systems, with established carriers fully optimized to use vehicles supported by an extensive network of facilities in suburban and rural areas (71). As city policies evolve to restrict vehicle movements (via pedestrianized areas and policies like congestion pricing), and regulators begin to address gaps in policy around these larger form bikes, the US may see more opportunities for financially sustainable multi-modal logistics companies to flourish.

In dense urban areas and certain cities in the US, delivery by 2-wheel e-bike and on foot has also increased. Companies like Amazon utilize walkers and hand carts to make deliveries in cities like NYC and San Francisco and Uber Eats and Doordash are both promoting incentives for drivers to utilize e-bikes in certain global markets (73). Cities continue to do their part by building out safe bike infrastructure and other amenities like e-bike battery charging stations that can incentivize the conversion out of vehicles and into e-bikes.

In addition to examples of delivery mode shifts that cities are advancing, this report offers examples of mode shifts that the private sector is advancing.

Shift in Operational Behavior: Consolidated Carrier Delivery to and Consumer Pickup from Parcel Lockers

Traditional operational behavior for carriers is to perform deliveries door-to-door, involving a vehicle making between a handful and hundreds of stops, often leading to inefficient routes and high fuel consumption (74). Lockers can create delivery density that can reduce the vehicle dwell time–the time a delivery vehicle stays parked while the driver performs deliveries to nearby buildings. By providing a secure storage system, parcel lockers can effectively reduce failed delivery attempts (and avoid porch piracy) and the need for additional delivery trips. Reduced dwell time and failed delivery attempts reduce time taken to perform deliveries, and hence lower costs for delivery firms, reduce delivery vehicle-miles traveled (VMT), and decrease traffic congestion and emissions (75). A delivery locker pilot in Seattle found that lockers can reduce the amount of time delivery trucks dwell at the curb by as much as 33 percent and reduce delivery times by as much as 78 percent (75).

U.S. cities can play a role in supporting parcel lockers and shifting operational behavior of both carriers and consumers- either directly or indirectly. Because parcel lockers can trigger shifts in the operational behavior of consumers in addition to carriers, cities can promote or incentivize the installation and use of lockers. These behavioral nudges are subtle changes to the choice architecture that can influence people's decisions without limiting their freedom of choice (e.g., without utilizing mandates or restrictions) (76). Parcel lockers can nudge consumers towards a more sustainable delivery choice by giving consumers the option to select a locker pick-up instead of home delivery.

That said, some last-mile delivery industry watchers argue that parcel lockers are unlikely to become as widespread in the U.S. as in Europe due several factors, including differences in urban density (77). For example, Milan, Italy, has a density of about 7,500 habitants per square kilometer. In U.S. cities like Houston, Texas, population density hovers in the 1,300 habitants per square kilometer. Perhaps it is unsurprising that New York City, the nation's densest city, is playing a leading role in the parcel locker arena (77). Cities must consider density factors to facilitate consumers to make non-motorized trips (e.g., on foot or bike) to pick up their locker packages.

Examples: Public Sector Advancing Mode Shift and Behavior Change

Key takeaway: E-bike use is growing dramatically in U.S. metro areas, especially for food delivery. City-run pilots are starting to emerge, providing subsidy, space, and services to support e-bike delivery.

EXAMPLE #1: CITIES ARE DEDICATING PHYSICAL PUBLIC SPACE FOR CARGO E-BIKE PARKING INFRASTRUCTURE AND PARCEL LOCKERS

Key takeaway: Cities can provide targeted incentives to influence the shift to new modes, like e-bikes, or behavioral changes, like picking up a package at a locker instead of receiving it at home. City-provided incentives can include infrastructure installation, allocation of public space, or in-kind services, such as permitting or marketing and community engagement support.

Cargo e-bike parking: Corrals and special loading zones

In 2019, the New York City Department of Transportation's (NYC DOT) launched a cargo e-bike pilot to encourage the use of cargo bicycles for commercial purposes like last-mile delivery. As part of the incentives built into the program design, NYC DOT not only let participating commercial cargo e-bikes park at existing commercial vehicle loading zones (CVLZs) with no meter fees but also installed designated cargo e-bike corrals in the public right-of-way (78). These corrals were usually built near facilities operated by cargo e-bike carriers and allowed cargo e-bikes to park while loading/unloading/staging the vehicles at the start and end of their trips or routes. The city has continued to build out this infrastructure, installing additional commercial cargo bike corrals in the densest parts of the city (78).

Publicly accessible lockers

NYC DOT is currently supporting chosen vendors from the private sector to install, operate, and manage common carrier parcel lockers (carrier agnostic deliveries) on public sidewalks throughout New York City (79). Currently, some 80 percent of NYC households receive at least one delivery per week and 20 percent receive four or more deliveries. Additionally, each day, 90,000 packages are reported stolen or lost in transit since many buildings lack secure areas for package deliveries, according to city officials (80). In addition to reducing package theft, the pilot explicitly aims to reduce delivery truck traffic and emissions by consolidating deliveries at central locations and reducing failed delivery attempts (81).

As of December 2024, the city had competitively contracted with one company, *GoLocker,* to operate and maintain the public lockers and oversee customer support and management of the technology (82). The city does not provide direct financial compensation, but helps the vendor to locate, site, and permit the locker installations on public sidewalks in addition to providing marketing, branding, and education of the benefits of shared use lockers to NYC residents and workers. The lockers are sited with pedestrian access in mind and considered a variety of factors. These factors included places based on land use,

concentration of buildings lacking mail or package rooms, and NYC Police Department package theft data in addition to other factors such as adequate circulation space, avoiding conflicts with street furniture, ensuring pedestrian flow, and avoiding obstruction of windows, fire escapes, or public art (80).

LockerNYC's Publicly-Accessible Outdoor Locker Provided by GoLocker, Photo credit: New York City Department of Transportation

EXAMPLE #2: CITIES SUBSIDIZING THE COST OF E-BIKES DELIVERIES

Key takeaway: Cities can provide subsidies to offset the start-up or transition costs of the private market (companies or independent workers) to move to commercial e-bikes for urban delivery. Both pilots targeted underserved communities- either geographically by business district, or by targeting food delivery workers and both pilots utilized available state funding from clean energy organizations to provide financial assistance.

Boston subsidizes operational costs of cargo e-bikes deliveries

Boston Delivers is a pilot based around the concept of neighborhood cargo e-bike delivery service for local businesses in the Allston Brighton neighborhood. The Boston Transportation Department competitively selected a logistics partner, Net Zero Logistics, to provide the cargo e-bikes, make the deliveries, and coordinate delivery logistics throughout the pilot term (83). It was designed as an 18-month pilot to run through the end of 2024 and supported via a grant provided by the Massachusetts Clean Energy Center (83).

During the pilot period, the city subsidized the cost of delivery for businesses serving the neighborhood, such as local restaurants and meal services for seniors and homebound or vulnerable residents. Additionally, pilot funds support the cost of the lease on the cargo e-bike depot, a parking garage located. The goals include: to support local businesses and organizations whose goods are being delivered by offering them a zero-emissions and free delivery options and to understand the business and operational conditions for sustainable logistics vendors like Net Zero Logistics to be successful in new markets (83).

Net Zero Logistics E-Bike Courier on a Coaster Cycles Trike in Boston, Photo credit: Net Zero Logistics

San Francisco subsidizes e-bikes for food delivery workers

Prior and during the pandemic, the San Francisco Local Agency Formation Commission conducted an Emerging Mobility Labor Study which collected data through surveys and interviews on gig-economy workers and drivers (84). The report included recommendations for future engagement including e-bike rebates. In 2023, San Francisco used a California Energy Commission grant to launch an e-bike delivery pilot that provides 2-wheel e-bikes, safety equipment (helmets, bike locks, bike bags), and bicycle training for up to 30 food delivery workers to make the switch to bike deliveries. In 2024, the San Francisco Environment Department tapped a U.S. Department of Energy grant to expand the pilot to more than 60 on-demand food delivery workers (85). Findings published in November 2024

showed a clear emissions benefit when switching from a vehicle to a bike, however, challenges remain. Participants found that there were mismatches between the size of the assigned order and the carrying capacity of the bike, flagged or deactivated accounts for speeding on the bike- despite the higher speed allowance of e-bikes, and longer wait times between orders (86). Encouragingly, these challenges pertain mostly to the algorithms and specifications within the apps and are not insurmountable.

Examples: Private Sector Advancing Mode and Behavior Shift

Key Takeaway: U.S.-based companies are acting even without government zero-emission mandates to translate into the U.S.—at a much smaller scale—than what is in Europe. Despite U.S. companies having led a decade of experimentation in zero-emission delivery modes, no clear path to scale has emerged for urban goods deliveries. Cities working toward zero-emission delivery face decisions about the role they will play with the private sector.

EXAMPLE #1: PRIVATE OPERATORS SPECIALIZING IN CARGO BIKE LOGISTICS

Key Takeaway: Some private retailers are seeking out tenders for cargo bike deliveries (Amazon, others) due to cost competitiveness and/or the sustainability benefits of cargo bike deliveries. Large-scale adoption of this mode is still quite limited in the U.S.

Since 2019, **Net Zero Logistics/Cornucopia Logistics**, a U.S.-based final-mile logistics company has been using cargo e-bikes with attached trailers to deliver groceries ordered online in NYC (87). Cargo bikes are well suited to grocery delivery trips because they are short and frequent, must often be performed quickly, and their destinations are typically residential areas. Today, the company operates about 300 cargo e-bikes, mostly e-bikes (with attached cargo trailers) and trikes, providing groceries and packages to 10,000 to 15,000 customers. **Dutch X** is another NYC-based final-mile logistics company that utilizes both cargo e-bikes and low-speed electric vehicles to deliver groceries and other parcels in NYC (88). There is emerging interest from crossover entities in Europe that are beginning to enter the NYC market with a cargo bike offering. Importantly, these operators all require urban real estate to store the bikes and trailers used and a safe and secure place to charge the bike batteries- a change from truck or van operations where vehicles can be stored outside of the city limits to save money.

B-Line E-Bike Delivery Trikes in Portland, Photo credit: Portland Bureau of Transportation

In contrast, **B-Line**, a Portland, Oregon-based cargo logistics company focuses primarily on wholesale deliveries (89). Business-to-business (B2B) deliveries have generally been performed using heavy motorized vehicles due to the larger volumes and lower shipment frequency than business-to-consumer deliveries. B-Line delivers food, groceries, beverages, and office supplies with a fleet of 12 cargo trikes out of a 20,000-square- foot-meter microhub, with 2,000 square feet of cold storage located 1.5 miles from downtown Portland (71).

EXAMPLE #2: PARCEL LOCKERS OFFER OPERATIONAL AND COST-SAVING BENEFITS TO CARRIERS AND RETAILERS

Key takeaway: Lockers can provide operational benefits (fewer vehicle stops, leading to reduced VMT and carbon emissions) especially if consumer retrievals are performed with a zero emission mode like walking or biking.

As noted earlier in this report, while parcel lockers are nowhere near as ubiquitous as in Europe, several private companies offer locker pick-ups in cities around the country.

A number of carriers operating the US have created locker access points for customers (Amazon, UPS Access Points, Fedex OnSite, and USPS Smart Lockers) (90). This “closed-system” model, also known as single-carrier lockers, are open to the public but can only be accessed by the carrier that owns and operates the locker. Across these four carriers, there are estimated to be more than 100,000 lockers across dozens of major metropolitan areas (90).

Public Locker Station Provided by Quadient, Photo credit: Parcel Pending by Quadient

Even more ubiquitous are lockers offered to customers as a receptacle to collect items purchased from a retail establishment online, commonly referred to as "buy online pick up in store" (BOPIS) or "click and collect" purchasing. Locker pick-up points within stores like Best Buy, Walmart, Home Depot and other major retailers can reduce friction for customer pick-up and are supported by vendors like Quadient/Parcel Pending and Harbor/Luxer One (among many others) (91). In addition to these in store pick-ups, a plethora of locker companies offer options for apartment buildings and other high-rise storage solutions.

Most common in Europe and Asia, a third model of locker pick-up is the "common-carrier" locker whereby multiple carriers can access a public locker point to stage or leave a package. While slowly emerging in the US, with companies like Parcel Pending and GoLocker, these lockers are open to the public and a variety of carriers (92). To access, the consumer uses a specific locker address (or in GoLocker's case, the address of their staging warehouse) instead of their home or work address (82). All three models can support reverse logistics flows like package returns- an increasing pain point for retailers.

EXAMPLE #3: NEW MOBILITY SMALL FORMS LIKE PERSONAL DELIVERY DEVICES (PDDs) AND DRONES DEPLOYING IN LIMITED MARKETS

Key Takeaway: New form factors are emerging, primarily PDDs and drones- almost all built to be 100% electric- as an alternative to traditional vehicle transport. These new

modes, slowly growing in scale in the U.S., offer innovative ways of sustainably delivering goods, especially small, lightweight parcels and non-batched items like food delivery.

There are still open questions as to how these devices will scale in cities: What restrictions or allowances will be made to enable urban deliveries? Will their numbers be limited in the same way cities have regulated scooter and bike share? Are there safety concerns that can be addressed via regulation?

Personal delivery devices (PDDs)

A personal delivery device (PDD) is an automated or remotely piloted device (commonly known as a sidewalk delivery robot) with storage space for smaller-size packages, food, or other delivery items (93). PDDs, depending on the company, may operate autonomously or be handled by remote operators (or a combination of the two) (94). College campuses have become the most prevalent proving grounds for PDDs - likely due to the reduced complexity of street crossings and vehicles. Over 20 states have passed legislation to date, allowing the use of PDDs on sidewalks and in most cases granting them the same rights as a pedestrian (vehicles must yield to PDD in a crosswalk, PDD can use sidewalk at a restricted speed) (95). Cities that have piloted and/or host limited use of sidewalk delivery robots include (but are not limited to) the District of Columbia, Santa Monica, Miami, Los Angeles, and Houston (96).

A SERVE Robot Picking up Food for Delivery, Photo credit: SERVE

Starship, based in San Francisco, uses PDDs to deliver food ordered on the GrubHub app on some 30 U.S. college campuses and uses a hybrid approach with both autonomy and remote operations (97). Kiwibot, headquartered in Miami, uses PDDs to deliver food at some 27 US college campuses via apps like Grubhub and Sodexo's Everyday and relies on a remote operator to move the robot (98). In contrast, SERVE, based in California's Silicon Valley relies on Level 4 autonomous operations to move the robot. SERVE is backed by Nvidia, Uber and other investors and is slated to roll out up to 2,000 PDDs in multiple U.S. cities in conjunction with Uber Eats (99). Its PDDs are primarily operating on city streets in Los Angeles and San Francisco (100). All companies operate fully electric robots.

Unmanned Aerial Vehicles (UAVs) or Drones

Unmanned aerial vehicles (commonly known as drones) may be autonomous, semi-autonomous, or remote-operated devices. Drones face weight and size limitations for effective flight limiting their use cases to smaller, lighter parcels like small items such as prescription drugs (96). Because drones utilize air space, their regulations are controlled primarily by the Federal Aviation Administration (FAA), the same body that regulates aircraft in the US and include licensing for operators, registration for devices, and rules around no fly zones for example (101). In 2024, new FAA rules were passed requiring the agency to create policy for "Beyond Visual Line of Sight" or BVLOS by September 2025- a change that might unlock an acceleration in commercial applications such as last-mile delivery as currently BVLOS operations are approved on a case by case basis (102).

UPS Using a Matternet Drone for Pharmaceutical Delivery, Photo credit: UPS Healthcare

In the private sector, the two retailers on the forefront of drone experimentation and ultra-fast (30 minutes are less) delivery are Amazon and Walmart. Amazon has taken an internal approach from the very beginning by designing its own custom Prime Air drones and launching commercially in 2022 in College Station, Texas. In 2024, they revealed the new MK30 drone device and expanded into the Phoenix suburbs (103). Walmart in contrast, has taken a vendor-based approach, partnering with many of the largest drone manufacturers and operators like Flytrex, DroneUp, Wing and Zipline operating in North Carolina; Texas, Arizona, and Florida; and Arkansas (104). In 2024, Walmart announced that it would soon reach an additional 1.8 million households in the Dallas Fort-Worth area (105). From the logistics sector, UPS is also experimenting with drone deliveries via its subsidiary Flight Forward which utilizes Matternet's M2 drone devices, obtaining BVLOS approval in 2023 (106). While much smaller in scale than Amazon or Walmart current operations, there is speculation that UPS is looking at drone technology that can integrate with its future trucks for an integrated and multi-modal approach to final mile delivery (107).

REAL ESTATE AND SPACE MANAGEMENT

REAL ESTATE AND SPACE MANAGEMENT

Characterized by interventions that leverage real estate, land use and/or space management to enable zero emissions delivery options.

Key Takeaway: Physical space is needed to enable the transition to zero emission delivery which may require cities to rethink approaches to policy and partnerships in order to unlock this vital piece of the puzzle.

Space is a scarce resource in cities but plays a critical role in the urban freight ecosystem. Trucks, vans, mopeds or cargo bikes used to distribute goods and materials take up space as they move, load and unload. Competition for real estate, curb and street access continue to spotlight and exacerbate the tensions surrounding street space allocation between passenger and freight activities (27). There is a growing understanding of the important role that logistics spaces play in improving urban livability and environmental sustainability (108).

Ecommerce is not the only trend linking space management and zero emission delivery, but it is a big part of the story. Goods distribution centers are pushing into cities to be

closer to customers, lowering transport costs and enabling faster deliveries. A recent Urban Freight Lab study focused on Amazon's recent build out of last-mile delivery stations in cities and showed that facilities have moved moderately closer to consumer households, forgoing the larger floorspace and lower rents that suburban locations traditionally accommodated (108). However, proximity to neighborhoods and customers raises greater concerns about inefficiencies. These inefficiencies generate negative externalities including climate emissions, air and noise pollution, congestion, and heightened collision risks, especially for vulnerable road users such as pedestrians and bicyclists (109). As ecommerce has shifted some e-retailers towards urban real estate stock (Figure 4), third-party logistics carriers (3PLs), although operating for decades, have grabbed up the larger real estate options, now representing over 30% of the U.S.'s bulk leasing activity (over 100,000 sq. ft.) since the pandemic's onset (13).

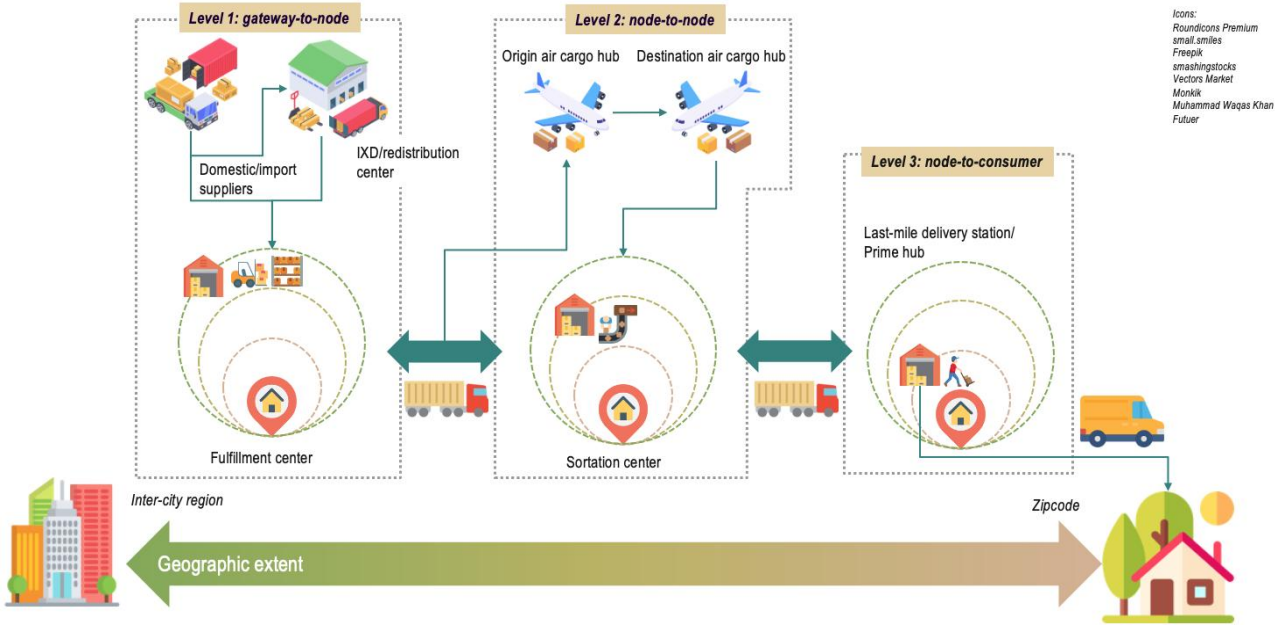


Figure 4. Land Use for Ecommerce, Image Source: Fried et al., 2024 (Adapted from MWPVL International, 2021) (110)

Cities have levers available that empower them to play a key role as "urban space managers" toward ZED transition. Those levers include managing the curb space, the public right of way through tools like street closures, pedestrianized areas, and "slow streets," and land use. Cities have jurisdiction to regulate both public space and private space (the latter through zoning.)

In the public right of way, a key authority cities have is controlling access to streets by certain vehicles. Residential areas, for instance, may allow for local traffic only which

includes passenger vehicles and local deliveries while disallowing larger freight vehicles. In most cases, though, street closures and pedestrianization are conceived of without urban freight in mind, leading to a shortage of available studies or data on the impacts on freight movement (111). There is evidence that these street designs can incentivize ZED and modal shift.

When roadways restrict general traffic flow it can incentivize modal shifts in urban freight fleets. For example, many fleets operating in dense areas of cities already opt for smaller vehicles in order to more easily navigate congested areas with competitive loading spaces. Research has yet to quantify the emission and pollution impacts of these types of legal access restrictions (e.g., pedestrian streets), particularly as it relates to freight. Pedestrianization efforts that aim to reduce emissions should pair with other policies and strategies to reduce simply shifting pollution and traffic congestion to other streets or parts of the city (112).

Notably, all the areas we focus on in this report–electrification, mode shift, and changes in operational and consumer behaviors–require space for urban logistics activities. Electrification requires space for charging infrastructure primarily at private facilities, such as warehouses and depots (113). Mode shift and other changes in operational behavior require space to store things like cargo e-bikes and cross-docking (moving goods from larger vehicles onto microfreight modes for last-mile delivery), space to install parcel lockers for consolidated delivery, and curb space for safer, non-motorized mobility during the "final 50 feet" (114).

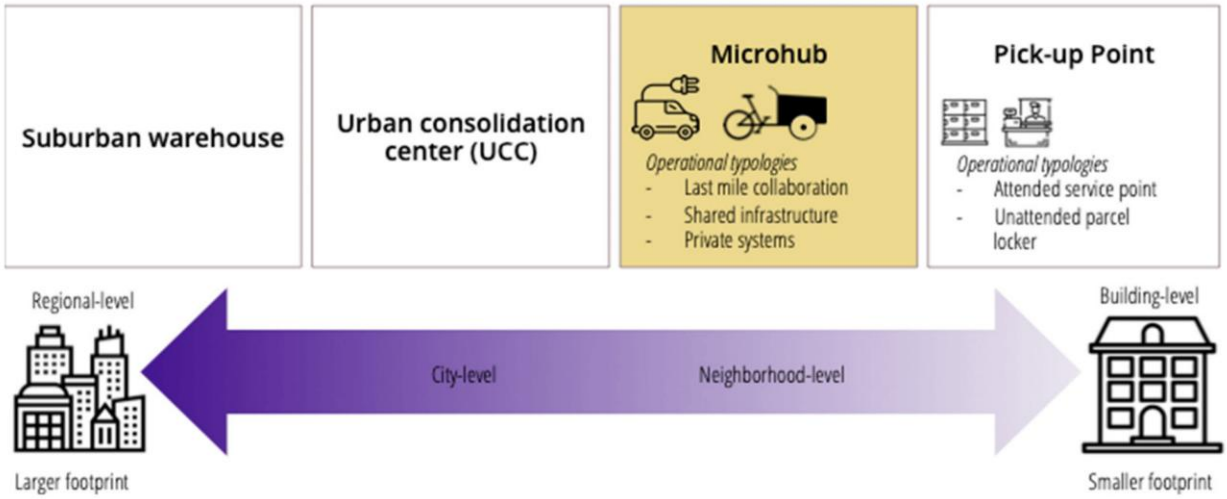


Figure 5. Hub Typology by Proximity, Image Source: Katsela et al, 2022 (115)

The real estate sector, for its part, is beginning to experiment more in the United States with creative repurposing of vacant commercial real estate and new business models (Figure 5) especially in dense, urban environments where space is limited (116). Private real estate developers and owners are also fielding more demand for charging infrastructure from a wide array of businesses seeking spaces that can support a mix of ICE and EVs. Entities like 3PLs are beginning to seek assurance that these spaces can meet the demand for EV charging capacity as their EV fleets expand (117). However, implementation of new builds or retrofits to support logistics use is still very nascent and remains expensive and risky. While there are more examples of public-private collaborations in Europe than the U.S. in this space, it is encouraging to see some of the examples highlighted below.

Examples: Cities Creating Space for ZED

Key takeaway: Cities need space not just for vehicles and charging, but for loading and unloading, too. Cities can use the tools they already have to regulate public space in support of ZED transition.

EXAMPLE #1: CITY USES PERMITTING FOR DELIVERY MICROHUBS ON PUBLIC RIGHT-OF-WAY AND GOVERNMENT-OWNED PROPERTY

Key takeaway: Cities can repurpose and lease public space to private actors to meet specific city-identified ZED goals.

NYC On-Street Microhubs, Photo credit: New York City Department of Transportation

The NYC Department of Transportation defines a microhub as "a logistics facility where goods are bundled inside the urban area boundaries, that serves a limited spatial range, and that allows a mode shift to low-emission vehicles or soft transportation modes (e.g., walking or cargo bikes) for last-mile deliveries" (118). NYC's three-year pilot, which is set to begin in 2025, includes both on-street and off-street microhubs that require DOT permits. Microhub operators pay the city fees to competitively secure both initial permits and renewals (118). The city regulates who qualifies as a microhub operator, where microhubs can locate, data sharing agreements, and what qualifies as a "sustainable mode of transportation" (e.g., cargo bikes, EVs, and hand carts) (118).

EXAMPLE #2: CITIES CAN ALLOCATE THE CURB FOR ZED VEHICLES

Key Takeaway: Cities can both reallocate curb space and differentiate pricing of this valuable delivery access point to incentivize ZED.

Cities can consider curbside pricing strategies for loading/unloading that can encourage ZE delivery, varying rates by time, congestion conditions, and (effectively) emissions, via green loading zones. Cities can also issue permits to use Commercial Vehicle Loading Zones (CVLZs). Since deliveries are a necessary activity, pricing for passenger parking will not eliminate freight trips but can lead to reduced curb demand from other vehicles that can benefit carriers and cities. Reducing cruising for parking by commercial vehicles can also reduce emissions (119).

Portland Zero Emission Loading Zone Signage, Photo credit: Portland Bureau of Transportation

Santa Monica, Los Angeles and Portland, Oregon have created zero emission (also referred to as green) commercial vehicle loading zones where certain commercial vehicle parking zones are set aside for ZED or LED vehicles (16). While Santa Monica relied on a voluntary approach during their pilot ZEDZ in 2021-22, Los Angeles and Portland have codified their green loading zones into legislation and exempted ZE vehicles from parking fees in these areas, giving companies preferred access and defraying some of the cost of ZE investment (120). Portland is the first city to incorporate the Open Mobility Foundation's Curb Data Specification (CDS) into their ZE loading zone program. Shared, standardized data allows the city to track zone usage and monitor and evaluate the usage and effectiveness of these zones to improve future implementation (121). Carriers in Portland reported that priority curb access could incentivize companies to add ZE vehicles into their fleet, especially if that switch resulted in greater efficiency and lowered challenges finding parking and loading in dense areas which might help them to lower delivery costs (122).

EXAMPLE #3: CITIES/REGIONS CAN REGULATE TRAFFIC-RELATED AIR POLLUTION FROM WAREHOUSES

Key takeaway: Policies that target indirect source pollution may be a pathway for U.S. cities and regions to explore given the legal constraints on regulating transportation vehicles by fuel type in this country. But agencies should explore these policies carefully; market structures in the freight sector can result in contracted drivers footing much of the bill, reducing compliance (123).

The Environmental Protection Agency (EPA) in fall 2024 approved a landmark Southern California rule that requires large warehouses to take steps to limit tailpipe emissions from trucks flowing in and out of the facility–or pay a fee (124). The Sierra Club suggests that the rule, adopted in 2021, has already pushed companies to acquire at least 815 new zero-emission trucks and install 172 truck charging stations, citing data from the South Coast Air Quality Management District (125). EPA approval makes the rule federally enforceable and could pave the way for similar rules beyond California, as warehouses expand to meet e-commerce demand (126). Illinois, New York state, and New York City are already proposing similar policies (127, 128, 129).

The rule above is part of an approach known as an Indirect Source Rule (ISR), that targets freight-generating land uses and related development and is reminiscent of transportation demand management (TDM)-related regulations that serve to impose rules and limits around transportation generated from new development (typically in downtowns and dense urban areas). Higher-emitting vehicles are levied higher fees and more energy-efficient modes can receive exemptions, discounts, and/or incentives (28). In Europe,

emission charges for ports and warehouses are often tied to other low/zero-emission zones (L/ZEZs). But in the U.S., ISRs are set apart from L/ZEZs, which, as already noted, pose major legal challenges. Only California can pursue waivers from the federal pre-emption on city and state policies that look to require emission standards outside federal guidelines (28).

Image Depicting Indirect Source Rule Measures in CA, Photo credit: San Joaquin Valley Air Pollution Control District

As of June 2024, only two California air quality control districts incorporate pollution pricing into mitigation targets: one in San Joaquin Valley and one covering large areas of Los Angeles, Orange, Riverside and San Bernardino counties (130). All new commercial and industrial developments above a certain size are included in San Joaquin Valley's ISR, generating fees that helped fund ZEV rebates (131). The second district is less comprehensive, only pricing freight trips from big warehouses (130).

Examples: Private Sector Reimaging Space for Logistics

Key takeaway: Businesses in the urban freight ecosystem increasingly understand the need to secure and invest in spaces that enable them to roll out new technologies and services. As demand for last-mile-related real estate grows, so too does the need for innovative and flexible private sector use of space to meet changing demands.

EXAMPLE #1: PRIVATELY RUN HUBS TO SUPPORT CARGO BIKE OPERATIONS

Key takeaway: Logistics operators managing cargo bike operations currently in the U.S. are already paying for and using urban real estate to store and charge bike fleets. U.K. real

estate developers are marketing explicitly to these cargo bike operators, given their prevalence in the market.

All of the U.S.-based cargo bike companies referenced earlier in this report (e.g., B-Line, Net Zero Logistics, and Dutch X) operate one or more microhubs to support their day-to-day operations. Specializing in wholesale food and beverage delivery, B-Line operates a 20,000 sq.ft. temperature-controlled microwarehouse in Portland, Oregon, enabling suppliers to bring goods directly to the hub for storage before deliveries are bundled and sent out via bikes (132). Net Zero Logistics and Dutch X run NYC-based microhubs from existing private parking facilities and other privately held real estate to store bikes and trailers, perform maintenance, and in some cases charge batteries. Such private space can be costly given its location in dense urban areas–the very areas where cargo bike delivery is feasible. Zoning and electrical constraints in certain facilities mean that e-bike batteries must be charged off-site. In the UK, some commercial real estate firms are promoting strategically located urban "hub" space for sustainable last-mile delivery inside London's Ultra Low Emission Zone (part of London's congestion pricing program (133).

EXAMPLE #2: RETROFITTING UNDERUSED OR VACANT RETAIL SPACE INTO LOGISTICS HUBS

Key Takeaway: Demand for faster delivery continues to push demand for urban logistics real estate closer to city centers. Developers are exploring repurposing existing commercial property to house urban logistics hubs. Such retrofits may provide flexibility for future ZE deployment. Cities could consider zoning to enable or inhibit this practice, depending on their goals and context.

Some real estate developers are converting vacant big box stores and malls into last-mile distribution centers. In Macon, Georgia, Ultimate Realty converted the six-building, 411,000-square foot Westgate Shopping Center into the now fully occupied Middle Georgia Industrial Park, within a few miles of Amazon and FedEx. A low purchase price, optimized location (and successful rezone to industrial use), local tax incentives, and a clear plan for adaptive reuse are factors that made the project economically viable (116).

But retail-to-industrial conversions in cities can pose significant space and cost challenges. While big box stores and malls already have infrastructure, it may not be in the right place or of the right size for last-mile distribution centers. On cost, experts urge focus on properties in land-constrained markets that can be secured far below reproduction cost (116). Regardless, a recent report from logistics company, Prologis, suggests such

conversions are unlikely to solve the shortage in urban logistics real estate supply, citing zoning issues and community opposition as real obstacles (134).

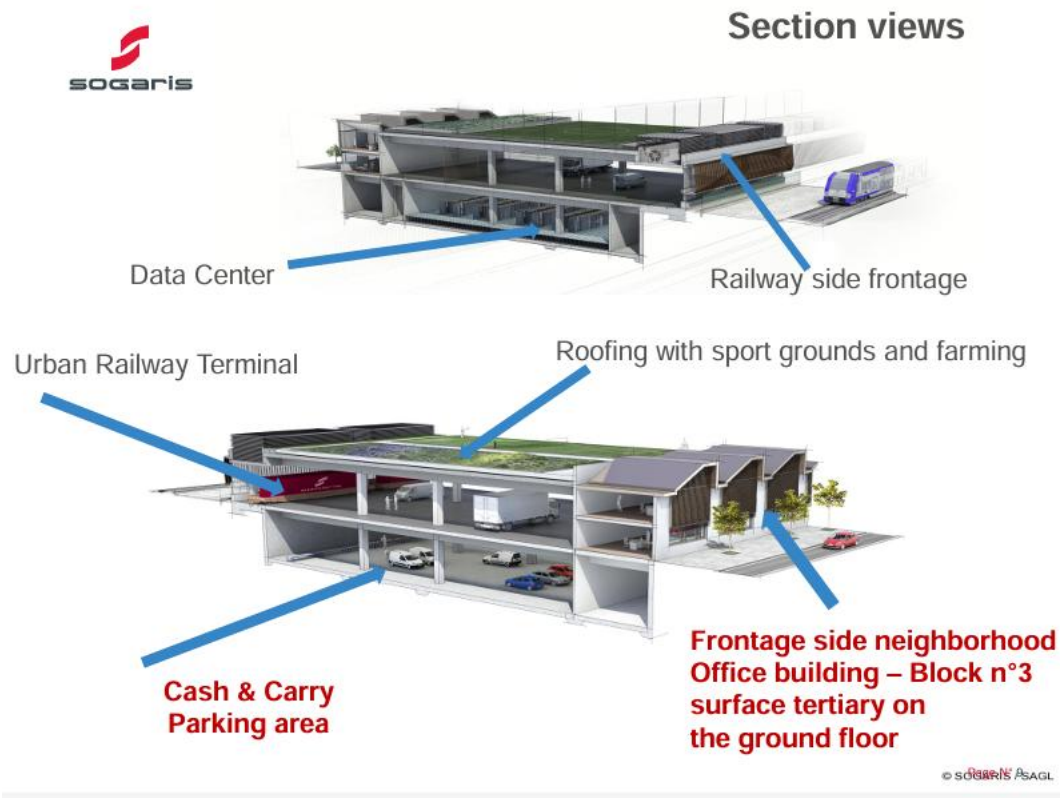


Image Depicting a Logistics Hotel in France, Photo credit: Sogaris Chapelle International

An approach more common in Europe that features public-private collaboration is that of French sustainable logistics real estate developer, Sogaris. The private, for-profit company is 70% owned by local governments (but receives no subsidy). Its Grenier Saint Lazare Urban Hub is a former automated car parking facility in the center of Paris converted into a 1,600 square-meter service and storage space and is frequently lauded as an exemplary urban logistics solution that integrates operations and aesthetics (11). Sogaris also developed "Logistics Hotel" Chapelle International, a mixed-use building with office and commercial space and logistics facilities (135). This type of public-private partnership is a model that could help to advance solutions in the US but is less tested to date.

EXAMPLE #3: URBAN CONSOLIDATION CENTERS TARGET RECEIVERS

Key Takeaway: Delivery consolidation led by the receivers of the goods may support the ZE transition as current examples tend to offer and/or market a ZE fleet.

Delivery consolidation can be driven by carriers or the receivers of the goods (consumers, retailers, etc.). The latter is less prevalent in the U.S. than Europe, though some argue that it is the receivers who can most impact urban delivery by shifting their requirements or demand (136, 137).

Microhub's Urban Consolidation Center for Residential Towers in Miami, Photo credit: Microhub

In Miami, an urban consolidation center dubbed "MicroHub" opened in fall 2024, targeting building managers and property owners at big residential towers that struggle to manage the growing volume of their resident's package deliveries. MicroHub uses a converted auto mechanic garage in Midtown Miami as an urban warehouse to receive goods and store and charge e-cargo bikes. Tenants input the warehouse address when completing their online shopping; packages there get sorted and stored; and then get delivered to tenants via e-cargo bike in a time window selected by the tenant (138).

In the Nordic countries, the facility management company Coor works directly with suppliers to map deliveries for reduced traffic congestion and CO2 emissions. Demand for goods is estimated and planned for certain time periods (consolidation) and then scheduled for regular deliveries on routes optimized for environmental sustainability (137).

KEY TAKEAWAYS AND CONCLUSION

Cities have an important role to play in the freight ecosystem and have strong local policy levers to influence the transition to zero emission delivery. In light of the shifting federal priorities underway at the time of publication, there is greater urgency and impetus for cities to work in collaboration with the private sector where possible on solutions, policies, and changes in the ZED space.

This report synthesizes the state of policy and practice of zero emission delivery in the U.S. as of January 2025. It offers a baseline for future work, and reveals levers U.S. cities can consider using to advance ZED. This report is not intended to guide cities toward a set of identified "best" practices, as we do not yet have analyses that would point to a given practice as "best." Rather, this report is intended to be descriptive, not prescriptive.

Cities must first start by taking time to understand *both* the macroeconomic trends associated with logistics in the U.S. and the highly localized and regionalized urban delivery networks and players that exist in their area. Investing in staff resources that focus on freight and delivery and that can lead stakeholder engagement is a needed first step for cities. Only then can cities assess the tools and incentives they can utilize effectively in their locality. Once tools and strategies are identified, cities must create clear roadmaps and timelines for implementation.

The move towards ZED from current operations does incur a sometimes steep transition cost and trade-offs are required of businesses to make switches toward zero emission alternatives. As this report highlights, there *are* private sector partners across real estate, automotive manufacturing, and logistics operations that are continuing to place an emphasis on the transition to electric vehicles, smaller form factors, and win-win solutions that improve efficiency, lower cost, and reduce negative externalities within cities. These changes take time, which should be factored into public sector roadmaps to give industry appropriate time for planning and operational transitions. Cities would be wise to seek out these private partners now, build and nurture long-term relationships, and experiment together in the coming years.

The research team created a framework in order to organize examples of zero emission delivery and the key levers to success: **(1) Electrification, (2) Mode Shift and Behavior Change, and (3) Real Estate and Space Management**. The policy and practice framework defined in this report clearly articulates the three key elements needed to progress on ZED. Our examples yielded a series of key takeaways (and related challenges) for cities to consider as they attempt to catalyze zero emission delivery.

Electrification – Understand and Incentivize

Key takeaway 1. Cities should understand the current (and emerging) challenges for delivery fleet electrification, current market conditions and vehicle offerings, and emerging models of public-private collaboration in order to design informed policy and create additional incentives to support the electrification of mixed delivery fleets.

> **Challenge:** The logistics industry is diverse in terms of players and markets and most cities do not have dedicated freight personnel.

Key takeaway 2. Cities can adopt initiatives and policies to advance EV adoption in the delivery sector. These can include using public sector purchasing power to prioritize zero emission vehicles, investing in public charging infrastructure that directly supports commercial delivery fleets, and pursuing holistic policy frameworks that catalyze private operators to make transitions to ZED.

> **Challenge:** Cities must stay within distinct legal boundaries while pursuing zero emission logistics. They cannot regulate vehicles operating in their jurisdiction based on fuel type so must pursue other avenues.

Key takeaway 3. Businesses are acting on corporate climate goals to invest in EVs and charging infrastructure, with start-ups and new lines of business stepping in to provide these assets and services.

> **Challenge:** EVs require major capital investments for both the vehicles and charging infrastructure. These might be overcome by large, legacy carriers, but smaller firms are challenged by steep, upfront costs.

Mode Shift and Behavior Change – Collaborate with Industry

Key takeaway 1. Smaller, electric vehicles and both operational and consumer-focused shifts towards consolidated pick ups can provide additional choices and methods for cities to achieve zero emission deliveries.

Challenge: Smaller devices have smaller payload and carrying volumes. Traditional vehicles can cover more expansive areas and travel on highways and multi-lane roads- especially useful in the U.S. where sprawl is prevalent.

Key takeaway 2. E-bike use is growing dramatically in U.S. metro areas, especially for food delivery. City-run pilots are starting to emerge, providing subsidy, space, and services to support e-bike delivery.

Challenge: Safe and connected cycling and walking infrastructure, while growing in the U.S. is still not ubiquitous.

Key takeaway 3. U.S.-based companies are acting even without government zero-emission mandates to translate into the U.S.—at a much smaller scale—than what is in Europe. Despite U.S. companies having led a decade of experimentation in zero-emission delivery modes, no clear path to scale has emerged for urban goods deliveries.

Challenge: Cities lack a cohesive strategy and toolkit to support the scaling of emerging ZED technology and encouragement of sustainable consumer behaviors (locker pick-ups, consolidated orders).

Real Estate and Space Management – Innovation is Key

Key takeaway 1. Physical space is needed to enable the transition to zero emission delivery which may require cities to rethink approaches to policy and partnerships in order to unlock this vital piece of the puzzle.

Challenge: Curb space especially is a highly valued public asset that serves diverse user needs and cities struggle to prioritize freight user needs with other demands.

Key takeaway 2. Cities need space not just for vehicles and charging, but for loading and unloading, too. Cities can use the tools they already have to regulate public space in support of ZED transition.

Challenge: Cities are beginning to experiment with innovative management of the public right-of-way like shared streets and pedestrian areas, but often face challenges from establishments and the private sector.

Key takeaway 3. Businesses in the urban freight ecosystem increasingly understand the need to secure and invest in spaces that enable them to roll out new technologies and services. As demand for last-mile-related real estate grows, so too does the need for innovative and flexible private sector use of space to meet changing demands.

Challenge: Despite interest, private real estate developers and owners have limited innovative or publicly-backed financing to de-risk experiments and trials of new space allocation or use.

ACKNOWLEDGEMENTS

This report was funded in part by the Department of Energy's Ride and Drive grant program, Los Angeles Cleantech Incubator (LACI), and the University of Washington's Urban Freight Lab.

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Recommended Citation:

Rula, K, Schnaiberg, L, Maxner, T, Shafiei Nia, H, Goodchild, A. (2025) The State of Zero Emission Delivery in the United States. Urban Freight Lab, University of Washington.

Appendix

Table 1. Summary of 2024 Federal GHG Reduction Goals by Transportation Mode

Transportation mode	Share of current emissions	Federal GHG reduction goals
Light Duty	49%	• Achieve 50% of new vehicle sales being zero-emission by 2030 supporting a pathway for full adoption, and ensure that new internal combustion engine vehicles are as efficient as possible • Deploy 500,000 EV chargers by 2030 • Ensure 100% federal fleet procurement be zero-emission by 2027
MD-HD Trucks and Buses	21%	• Aim to have 30% of new vehicle sales be zero-emission by 2030 and 100% by 2040 • Ensure 100% federal fleet procurement is zero-emission by 2035
Offroad, Rail, Maritime, Aviation, Pipelines	30%	

Source: The U.S. National Blueprint for Transportation Decarbonization (32)

Table 2. Vehicle Classification and Original Equipment Manufacturers (OEM) Zero-Emission Model Availability

Vehicle Type	Classification (of Vehicle)	Zero-Emission Models Available
Cargo Van	Class 2b/3 Cargo Van	23
Medium-Duty Step Van	Class 3-8 Step Van	*Approximately 15*
Medium-Duty Truck	Class 3-6 Rural/Intercity	73
Heavy-Duty Truck	Class 7-8 Over the Road (OTR) or Long-Haul Trucks Class 7-8 Urban/Regional Haul Class 7-8 Work Site Support	32

Source: CALSTART, 2024 (20)

Table 3. OEM Commitments to U.S. ZEV Sales and Carbon Neutrality

OEM	ZEV Target	Target Year
Ford	100% fossil-free new vehicle sales	2040
General Motors	Sell zero-emission versions of all Heavy-Duty trucks	2035
Daimler Trucks North America	All new trucks (and buses) will be carbon neutral	2039

PACCAR	Net-zero GHG emissions	2050
Volvo Trucks	100% fossil-free product sales	2040
Navistar	100% of new vehicle sales to be zero-emission	2040
Hyundai	Carbon neutrality	2045
Cummins	Reduce Scope 3 absolute lifetime GHG emissions from newly sold products by 25%	2030

Source: CALSTART, 2024 (20)

REFERENCES

1. Tomer A, Kane J. Mapping Freight: The Highly Concentrated Nature of Goods Trade in the United States [Internet]. Washington, DC: Brookings Institution; 2016 [cited 2025 May 19]. Available from: https://www.brookings.edu/wp-content/uploads/2016/06/Srvy_GCIFreightNetworks_Oct24.pdf

2. Transport Decarbonisation Alliance. Zero-Emission Zones in the City: Don't Wait to Start with Freight! [Internet]. 2023 [cited 2025 May 19]. Available from: https://tda-mobility.org/wp-content/uploads/2023/06/Zero-Emission-Zones-in-the-City-Dont-Wait-to-Start-with-Freight.pdf

3. United States Department of Transportation. DOT Report to Congress: Decarbonizing U.S. Transportation [Internet]. 2024 Jul [cited 2025 May 19]. Available from: https://www.transportation.gov/sites/dot.gov/files/2024-07/DOT%20Report%20to%20Congress%20Decarbonizing%20US%20Transportation%20072924%20final.pdf

4. Dablanc L. City Logistics. In: Richardson D, Castree N, Goodchild MF, Kobayashi A, Liu W, Marston R, editors. International Encyclopedia of Geography: People, the Earth, Environment and Technology [Internet]. Wiley Online Library; 2019 [cited 2025 May 19]. Available from: https://doi.org/10.1002/9781118786352.wbieg0137.pub2

5. Ranjbari A, Goodchild A, McCormack E, Hurwitz D, Verma R, Liu Y, et al. Insights from Driver Parking Decisions in a Truck Simulator to Inform Curb Management Decisions [Internet]. Seattle, WA: PacTrans; 2023 [cited 2025 May 19]. Available from: https://depts.washington.edu/pactrans/research/projects/insights-from-driver-parking-decisions-in-a-truck-simulator-to-inform-curb-management-decisions/

6. Higgs G. Revealing the Secret Emissions of E-commerce [Internet]. Clean Mobility Collective (CMC) and Stand.earth Research Group; 2022 [cited 2025 May 19]. Available from: https://clean-mobility.org/wp-content/uploads/2022/07/Secret-Emissions-of-ECommerce.pdf

7. Viu-Roig M, Alvarez-Palau EJ. The Impact of E-Commerce-Related Last-Mile Logistics on Cities: A Systematic Literature Review. Sustainability. 2020;12(16):6492. https://doi.org/10.3390/su12166492

8. Boogaard H, et al. Long-term exposure to traffic-related air pollution and selected health outcomes: A systematic review and meta-analysis. Environ Int. 2022;164:107262. https://doi.org/10.1016/j.envint.2022.107262

9. Tessum CW, et al. PM2.5 polluters disproportionately and systemically affect people of color in the United States. Sci Adv. 2021;7:eabf4491. https://doi.org/10.1126/sciadv.abf4491

10. Jaller M, Pahwa A. Coping with the Rise of E-commerce Generated Home Deliveries through Innovative Last-mile Technologies and Strategies [Internet]. UC Davis: National Center for Sustainable Transportation; 2023 [cited 2025 May 19]. Available from: http://dx.doi.org/10.7922/G2057D87

11. International Transport Forum (ITF). Urban Logistics Hubs: Summary and Conclusions. ITF Roundtable Reports, No. 195. Paris: OECD Publishing; 2024.

12. Rodrigue JP. The Geography of Transport Systems. 6th ed. New York: Routledge; 2024. 402 p. ISBN: 9781032380407. https://doi.org/10.4324/9781003343196

13. CBRE. The Global Outsourcing of Warehousing: 3PLs Dominate Demand for Industrial & Logistics Space [Internet]. 2024 Feb 28 [cited 2025 May 19]. Available from: https://www.cbre.com/insights/reports/the-global-outsourcing-of-warehousing

14. Brito J. No fleet left behind: Barriers and opportunities for small fleet zero-emission trucking [Internet]. 2022 Oct [cited 2025 May 19]. Available from: https://theicct.org/wp-content/uploads/2022/10/small-fleet-ze-trucking-oct22.pdf

15. Wang X, Wong YD, Chen T, Yuen KF. Consumer Logistics in Contemporary Shopping: A Synthesised Review. Transp Rev. 2023;43(3):502–32. https://doi.org/10.1080/01441647.2022.2131010

16. Maxner T, Dalla Chiara G, Goodchild A. Identifying the challenges to sustainable urban last-mile deliveries: Perspectives from public and private stakeholders. Sustainability. 2022.

17. UK Department for Transport. Road Traffic Statistics - London Region [Internet]. 2023 [cited 2025 May 19]. Available from: https://roadtraffic.dft.gov.uk/regions/6

18. Giron-Valderrama G, Goodchild A. Characterization of Seattle's commercial traffic patterns: A Greater Downtown Area and Ballard/Interbay vehicle count and evaluation. Seattle: Supply Chain Transportation and Logistics Center, University of Washington; 2020 Dec.

19. Quak H, van Duin JHR. The influence of road pricing on physical distribution in urban areas. Procedia Soc Behav Sci. 2010;2(3):6141–53. https://doi.org/10.1016/j.sbspro.2010.04.026

20. Richard M, Lund J, Al-Alawi A. Zeroing in on zero-emission trucks: The state of the U.S. market. CALSTART; 2024 Jan. Available from: https://calstart.org/wp-content/uploads/2024/01/ZIO-ZET-2024_010924_Final.pdf

21. Richard J. Zeroing in on zero-emission trucks. CALSTART; 2025 Jan. Available from: https://calstart.org/wp-content/uploads/2025/01/January2025_ZIO-ZET_MarketUpdate_Final.pdf

22. The International Council on Clean Transportation. Zero-emission bus and truck market in the United States: A 2022–2023 update. Washington (DC): ICCT; 2024 Jun. Available from: https://theicct.org/wp-content/uploads/2024/06/ID-156-%E2%80%93-US-R2Z-Market-Spotlight_final.pdf

23. Amazon. Amazon to invest more than €1 billion to electrify its European transportation network and reduce carbon emissions [Internet]. Luxembourg: Amazon EU; [cited 2025 May 20]. Available from: https://www.aboutamazon.eu/news/transportation/amazon-to-invest-more-than-1-billion-to-electrify-its-european-transportation-network-and-reduce-carbon-emissions

24. Aifandopoulou G, Xenou E. Sustainable urban logistics planning. European Platform on Sustainable Urban Mobility Plans. NOVELOG Project, European Commission; 2019.

25. Maxner T, Dalla Chiara G, Goodchild A. The state of sustainable urban last-mile freight planning in the United States. J Am Plann Assoc. 2024;91(1):88–101. https://doi.org/10.1080/01944363.2024.2324096

26. Turner AE. Legal tools for achieving low traffic zones (LTZs): LEZ, ULEZ & congestion pricing in the U.S. law context. Environ Law Rep. 2020;50:10329. Available from: https://scholarship.law.columbia.edu/sabin_climate_change/59

27. International Transport Forum (ITF). The freight space race: curbing the impact of freight deliveries in cities. Paris: OECD Publishing; 2022. (International Transport Forum Policy Papers; No. 109).

28. Turner AE. Cities, e-commerce & public health: 3 legal pathways to limiting freight vehicle emissions. Sabin Center for Climate Change Law; 2024 Jun. Available from: https://scholarship.law.columbia.edu/sabin_climate_change/228

29. Minjares R, Rodríguez F, Sen A, Braun C. Infrastructure to support a 100% zero-emission tractor-trailer fleet in the United States by 2040. Washington (DC): International Council on Clean Transportation; 2021 Sep. Available from: https://theicct.org/sites/default/files/publications/ze-tractor-trailer-fleet-us-hdvs-sept21.pdf

30. McKenzie L, Di Filippo J, Rosenberg J, Nigro N. U.S. vehicle electrification infrastructure assessment: medium- and heavy-duty truck charging. Washington (DC): Atlas Public Policy; 2021 Nov 12. Available from: https://atlaspolicy.com/wp-content/uploads/2021/11/2021-11-12_Atlas_US_Electrification_Infrastructure_Assessment_MD-HD-trucks.pdf

31. American Trucking Associations. Economics and industry data [Internet]. Arlington (VA): ATA; [cited 2025 May 20]. Available from: https://www.trucking.org/economics-and-industry-data

32. U.S. Department of Energy. The U.S. National Blueprint for Transportation Decarbonization: A joint strategy to transform transportation [Internet]. Washington (DC): DOE; 2023 Jan. Available from: https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

33. CALSTART. Memorandum of understanding on zero-emission medium- and heavy-duty vehicles [Internet]. Global Drive to Zero; 2022 Nov. Available from: https://globaldrivetozero.org/mou-nations/

34. Joint Office of Energy and Transportation. National Zero-Emission Freight Corridor Strategy [Internet]. Washington (DC): Drive Electric; 2024 Sep. Available from: https://driveelectric.gov/files/zef-corridor-strategy.pdf

35. Fisher T. Fifteen states and D.C. pledge 100% zero-emission trucks by 2050 [Internet]. Landline Media; 2020 Jul 14. Available from: https://landline.media/fifteen-states-and-d-c-pledge-100-zero-emission-trucks-by-2050/

36. McNamara M. Understanding California's advanced clean truck regulation [Internet]. RMI; 2023 Jun 27. Available from: https://rmi.org/understanding-californias-advanced-clean-truck-regulation/

37. Advanced Clean Tech News. CARB set to repeal ACF rule following legal challenges [Internet]. 2025 May 8. Available from: https://www.act-news.com/news/carb-set-to-repeal-acf-rule-following-legal-challenges/

38. Lepre N. Estimated $30 billion committed to medium and heavy-duty charging infrastructure in the United States [Internet]. Atlas EV Hub; 2025 Jan 26. Available from: https://www.atlasevhub.com/data-stories/estimated-30-billion-committed-to-medium-and-heavy-duty-charging-infrastructure-in-the-united-states/

39. U.S. Department of Energy. Federal and state laws and incentives [Internet]. Alternative Fuels Data Center; [cited 2025 May 20]. Available from: https://afdc.energy.gov/laws/12744

40. U.S. Federal Highway Administration. Charging and fueling infrastructure discretionary grant program [Internet]. Washington (DC): FHWA; [cited 2025 May 20]. Available from: https://www.fhwa.dot.gov/environment/cfi/

41. Joint Office of Energy and Transportation. Places to charge: Stations growth data [Internet]. Drive Electric; [cited 2025 May 20]. Available from: https://driveelectric.gov/stations-growth

42. Electrification Coalition. Federal EV policy [Internet]. [cited 2025 May 20]. Available from: https://electrificationcoalition.org/work/federal-ev-policy/

43. Electrification Coalition. Electrification of fleets [Internet]. [cited 2025 May 20]. Available from: https://electrificationcoalition.org/work/ev-fleets/

44. Government Fleet Staff. Over 300 mayors commit to electrify at least 50% of fleets by 2030 [Internet]. 2024 Aug 29. Available from: https://www.government-fleet.com/10227305/over-300-mayors-commit-to-electrify-at-least-50-of-fleets-by-2030

45. Joint Office of Energy and Transportation. Places to charge: Station growth news [Internet]. Drive Electric; [cited 2025 May 20]. Available from: https://driveelectric.gov/news/places-to-charge

46. Office of the Mayor, City of New York. Mayor Adams announces plan to combat lithium-ion battery fires, promote safe electric micromobility usage [Internet]. 2023 Mar 20. Available from: https://www.nyc.gov/office-of-the-mayor/news/195-23/mayor-adams-plan-combat-lithium-ion-battery-fires-promote-safe-electric-micromobility

47. New York City Department of Transportation. Safer charging, safer deliveries: Lessons from NYC DOT's public e-bike charging pilot [Internet]. [cited 2025 May 20]. Available from: https://www.nyc.gov/html/dot/downloads/pdf/safer-charging-safer-deliveries.pdf

48. Marchetti E, Antonelli C. Social aspects of low emission zones: Milan case study [Internet]. Institute for European Environmental Policy; 2024 Jun. Available from: https://ieep.eu/wp-

content/uploads/2024/06/Social-aspects-of-low-emission-zones-Milan-case-study-IEEP-2024.pdf

49. Urban Access Regulations. Milano LEZ Area B [Internet]. 2024 [cited 2025 May 20]. Available from: https://urbanaccessregulations.eu/countries-mainmenu-147/italy-mainmenu-81/milano-lez-area-b#delivery

50. Metropolitan Transportation Authority. Congestion relief zone [Internet]. [cited 2025 May 20]. Available from: https://www.mta.info/fares-tolls/tolls/congestion-relief-zone

51. Nolan S. PepsiCo expands electric fleet adding Tesla and Ford EVs [Internet]. EV Magazine; 2024 May 22 [cited 2025 May 20]. Available from: https://evmagazine.com/articles/pepsico-expands-electric-fleet-adding-tesla-and-ford-evs

52. EV Charging Summit. 4 of the top fastest-growing private and municipal fleets [Internet]. 2024 Jun 14 [cited 2025 May 20]. Available from: https://evchargingsummit.com/blog/fastest-growing-private-and-municipal-fleets/

53. SparkCharge. Charging-as-a-service (CaaS) [Internet]. [cited 2025 May 20]. Available from: https://www.sparkcharge.io/charging-as-a-service-caas

54. FleetOwner. Forum Mobility provides charging for new electric truck program [Internet]. 2024 Mar 18 [cited 2025 May 20]. Available from: https://www.fleetowner.com/emissions-efficiency/article/21284613/forum-mobility-named-charging-solutions-partner-for-one-electric-truck-program

55. Forum Mobility. Forum Mobility hosts ribbon cutting ceremony for FM Harbor electric truck charging depot at the Port of Long Beach [Internet]. 2025 Jan 23 [cited 2025 May 20]. Available from: https://forummobility.com/media-and-events/

56. Climate United. Climate United launches historic $250M electric drayage truck program [Internet]. 2024 Oct 29 [cited 2025 May 20]. Available from: https://weareclimateunited.org/news/electric-drayage-truck-program-announcement

57. PYMNTS. Amazon surpasses UPS to become largest delivery service in US [Internet]. 2023 Nov 27 [cited 2025 May 20]. Available from: https://www.pymnts.com/news/delivery/2023/amazon-surpasses-ups-to-become-largest-delivery-service-in-us/

58. Amazon Staff. How Amazon's DSP program has created $26 billion in revenue for owners [Internet]. Amazon; 2022 Aug 19 [cited 2025 May 20]. Available from: https://www.aboutamazon.com/news/transportation/how-amazons-dsp-program-has-created-26-billion-in-revenue-for-owners

59. Amazon Logistics. Frequently asked questions [Internet]. [cited 2025 May 20]. Available from: https://logistics.amazon.com/marketing/faq

60. Amazon Staff. Everything you need to know about Amazon's electric delivery vans from Rivian [Internet]. 2024 Nov 27 [cited 2025 May 20]. Available from: https://www.aboutamazon.com/news/transportation/everything-you-need-to-know-about-amazons-electric-delivery-vans-from-rivian

61. E&E News. Inside Amazon's EV charging challenge [Internet]. 2024 Jan 10 [cited 2025 May 20]. Available from: https://www.eenews.net/articles/inside-amazons-ev-charging-challenge/

62. IKEA. Zero emissions for home deliveries [Internet]. [cited 2025 May 20]. Available from: https://www.ikea.com/global/en/our-business/sustainability/zero-emissions-for-home-deliveries

63. IKEA. IKEA U.S. and Electrify America announce collaboration for ultra-fast public and fleet charging stations [Internet]. 2022 Aug 11 [cited 2025 May 20]. Available from: https://www.ikea.com/us/en/newsroom/corporate-news/ikea-u-s-electrify-america-announce-collaboration-ultra-fast-public-and-fleet-charging-stations-pubbe485af0/

64. Global Fleet. How IKEA is electrifying its car and delivery fleets [Internet]. 2023 May 29 [cited 2025 May 20]. Available from: https://www.globalfleet.com/en/new-energies/europe/features/how-ikea-electrifying-its-car-and-delivery-fleets

65. Uber. Sustainability at Uber [Internet]. [cited 2025 May 20]. Available from: https://www.uber.com/us/en/about/sustainability/

66. EVgo. Uber partnership [Internet]. [cited 2025 May 20]. Available from: https://www.evgo.com/uber/

67. Middleton N. Uber spurs EV switch for drivers with new grants and free charging [Internet]. EV Fleet World; 2024 May [cited 2025 May 20]. Available from: https://evfleetworld.co.uk/uber-spurs-ev-switch-for-drivers-with-new-grants-and-free-charging/

68. Toll M. How swappable batteries are helping Uber Eats deliver your food faster [Internet]. Electrek; 2023 Dec 18 [cited 2025 May 20]. Available from: https://electrek.co/2023/12/18/how-swappable-batteries-are-helping-uber-eats-deliver-your-food-faster/

69. Dalla Chiara G, Krutein KF, Ranjbari A, Goodchild A. Understanding urban commercial vehicle driver behaviors and decision making. Transp Res Rec. 2021;036119812110035. https://doi.org/10.1177/03611981211003575

70. Anderson ML, Auffhammer M. Pounds that kill: the external costs of vehicle weight. Rev Econ Stud. 2014;81(2):535–71. Available from: http://www.jstor.org/stable/43551573

71. Dalla Chiara G, Verma R, Rula K, Goodchild A. Biking the goods: How North American cities can prepare for and promote large-scale adoption of cargo e-bikes. Urban Freight Lab, University of Washington; 2023.

72. Future Market Insights, Inc. Cargo bike market growth – trends & forecast 2024–2034 [Internet]. 2024 Nov [cited 2025 May 20]. Available from: https://www.futuremarketinsights.com/reports/cargo-bike-

market

73. Amazon. How Amazon packages are delivered in densely populated areas like New York City with e-bikes and on foot [Internet]. 2025 May 9 [cited 2025 May 20]. Available from: https://www.aboutamazon.com/news/transportation/amazon-delivery-new-york-nyc

74. DHL. How parcel lockers can contribute to greener logistics [Internet]. 2023 Sep 20 [cited 2025 May 20]. Available from: https://lot.dhl.com/parcel-lockers-greener-logistics/

75. Ranjbari A, Diehl C, Dalla Chiara G, Goodchild A. Do parcel lockers reduce delivery times? Evidence from the field. *Transp Res Part E Logist Transp Rev.* 2023;172:103070. https://doi.org/10.1016/j.tre.2023.103070

76. Limbu S. How can behavioral science encourage sustainable decisions? [Internet]. Earth.org; 2024 Apr 12 [cited 2025 May 20]. Available from: https://earth.org/how-can-behavioral-science-encourage-sustainable-decisions/

77. Pharand A. OPINION: The limitations of parcel lockers in North America [Internet]. Parcel and Postal Technology International; 2024 Jun 24 [cited 2025 May 20]. Available from: https://www.parcelandpostaltechnologyinternational.com/opinion/opinion-the-limitations-of-parcel-lockers-in-north-america.html

78. New York City Department of Transportation. Commercial cargo bike pilot evaluation [Internet]. 2021 May [cited 2025 May 20]. Available from: https://www.nyc.gov/html/dot/downloads/pdf/commercial-cargo-bicycle-pilot-evaluation-report.pdf

79. New York City Department of Transportation. NYC DOT to launch initiative to cut down on package thefts and reduce negative environmental and safety impacts of truck deliveries [Internet]. 2023 Jun 30 [cited 2025 May 20]. Available from: https://www.nyc.gov/html/dot/html/pr2023/dot-launch-initiative-packages-enviromental-trucks.shtml

80. Office of the Mayor, City of New York. Mayor Adams, DOT Commissioner Rodriguez launch LockerNYC to combat package theft and reduce delivery truck traffic [Internet]. 2024 Apr 10 [cited 2025 May 20]. Available from: https://www.nyc.gov/office-of-the-mayor/news/266-24/mayor-adams-dot-commissioner-rodriguez-launch-lockernyc-combat-package-theft-reduce

81. New York City Department of Transportation. Deliveries in NYC: LockerNYC program [Internet]. [cited 2025 May 20]. Available from: https://www.nyc.gov/html/dot/html/motorist/deliveries.shtml#lockernyc

82. GoLocker. LockerNYC service information [Internet]. [cited 2025 May 20]. Available from: https://www.golocker.com/locker-nyc

83. City of Boston. Boston Delivers program [Internet]. [cited 2025 May 20]. Available from: https://www.boston.gov/departments/transportation/boston-delivers

84. San Francisco Local Agency Formation Commission. Preliminary recommendations: how to address problematic labor, safety, health and transportation issues among ride-hail and food delivery workers [Internet]. 2020 May [cited 2025 May 20]. Available from: https://www.sfgov.org/lafco/sites/default/files/lfc051520_item6.pdf

85. San Francisco Environment Department. E-bike delivery pilot [Internet]. [cited 2025 May 20]. Available from: https://www.sfenvironment.org/ebike-delivery-pilot

86. San Francisco Environment Department. Electric bike pilot for delivery workers [Internet]. 2024 Nov [cited 2025 May 20]. Available from: https://www.sfenvironment.org/media/14953

87. NetZeroLog. Homepage [Internet]. [cited 2025 May 20]. Available from: https://www.netzerolog.com/

88. Dutch-X. Shifting gears: Dutch-X and GEM set the standard for urban logistics [Internet]. [cited 2025 May 20]. Available from: https://www.dutchx.com/blog/shifting-gears-dutchx-and-gem-set-the-standard-for-urban-logistics/

89. B-Line PDX. Homepage [Internet]. [cited 2025 May 20]. Available from: https://b-linepdx.com/

90. Atkinson H. Are delivery lockers finally going to proliferate in the U.S.? [Internet]. Supply Chain Brain; 2024 Jul 10 [cited 2025 May 20]. Available from: https://www.supplychainbrain.com/articles/40007-are-delivery-lockers-finally-going-to-proliferate-in-the-us

91. Parcel Pending. Homepage [Internet]. [cited 2025 May 20]. Available from: https://www.parcelpending.com/

92. Scruggs G. University of Washington studies future of urban package delivery with lockers and street sensors [Internet]. GeekWire; 2020 Oct 2 [cited 2025 May 20]. Available from: https://www.geekwire.com/2020/university-washington-studies-future-urban-package-delivery-lockers-street-sensors/

93. Fisher N. An emerging issue: Robot delivery devices may be coming to a neighborhood near you [Internet]. MRSC; 2021 Sep 2 [cited 2025 May 20]. Available from: https://mrsc.org/stay-informed/mrsc-insight/september-2021/robot-delivery-devices-coming-soon

94. Urbanism Next. Drones [Internet]. [cited 2025 May 20]. Available from: https://www.urbanismnext.org/technologies/drones

95. Pedestrian and Bicycle Information Center. Personal Delivery Devices (PDDs) Legislative Tracker (Version 1.0) [Internet]. [cited 2025 May 20]. Available from: https://www.pedbikeinfo.org/resources/resources_details.cfm?id=5314

96. Urban Freight Lab. What is microfreight? Downsizing delivery for a multimodal and sustainable future [Internet]. 2023 Jun 20 [cited 2025 May 20]. Available from: https://www.goodsmovement2030.com/post/microfreight-downsizing-delivery-for-a-multimodal-and-sustainable-future

97. Starship Technologies. University campuses [Internet]. [cited 2025 May 20]. Available from: https://www.starship.xyz/university-campuses/

98. Restaurant Technology News. Kiwibot lands $10 million to expand its fleet of restaurant food delivery robots [Internet]. 2023 Feb 26 [cited 2025 May 20]. Available from: https://restauranttechnologynews.com/2023/02/kiwibot-lands-10-million-to-expand-its-fleet-of-restaurant-food-delivery-robots/

99. Bellan R. Nvidia invests $10M in sidewalk robot delivery company Serve Robotics [Internet]. TechCrunch; 2022 Mar 8 [cited 2025 May 20]. Available from: https://techcrunch.com/2022/03/08/nvidia-invests-10m-in-sidewalk-robot-delivery-company-serve-robotics/

100. Serve Robotics. Uber scaling partnership [Internet]. [cited 2025 May 20]. Available from: https://www.serverobotics.com/uber-scaling

101. Drone U. New drone laws in the USA [updated in 2025] [Internet]. 2025 Apr 24 [cited 2025 May 20]. Available from: https://www.thedroneu.com/blog/usa-drone-laws-regulations-by-state/

102. Drone Launch Academy. Upcoming changes to operating a drone beyond the visual line of sight [Internet]. 2024 Aug 27 [cited 2025 May 20]. Available from: https://dronelaunchacademy.com/resources/upcoming-changes-to-operating-a-drone-beyond-the-visual-line-of-sight/

103. McNabb M. Amazon extends drone delivery service to Phoenix area [Internet]. DroneLife; 2024 Nov 5 [cited 2025 May 20]. Available from: https://dronelife.com/2024/11/05/amazon-extends-drone-delivery-service-to-phoenix-area/

104. Walmart. Walmart drone delivery by the numbers [Internet]. 2023 Jan 5 [cited 2025 May 20]. Available from: https://corporate.walmart.com/news/2023/01/05/walmart-drone-delivery-by-the-numbers

105. Walmart. Sky high ambitions: Walmart to make largest drone delivery expansion of any U.S. retailer [Internet]. 2024 Jan 9 [cited 2025 May 20]. Available from: https://corporate.walmart.com/news/2024/01/09/sky-high-ambitions-walmart-to-make-largest-drone-delivery-expansion-of-any-us-retailer

106. Mogg T. FAA gives UPS' drone delivery efforts a big boost [Internet]. Digital Trends; 2023 Sep 6 [cited 2025 May 20]. Available from: https://www.digitaltrends.com/news/drone-delivery-breakthrough-for-ups/

107. Wolf H. Who are the big 3 in U.S. drone delivery? [Internet]. Forbes; 2024 Jan 26 [cited 2025 May 20]. Available from: https://www.forbes.com/sites/harrisonwolf/2024/01/26/who-are-the-big-3-in-us-drone-delivery/

108. Fried T, Goodchild A. E-commerce and logistics sprawl: a spatial exploration of last-mile logistics platforms. J Transp Geogr. 2023;112:103692. https://doi.org/10.1016/j.jtrangeo.2023.103692

109. Browne M, Allen J, Nemoto T, Patier D, Visser J. Reducing social and environmental impacts of urban freight transport: a review of some major cities. *Procedia Soc Behav Sci.* 2012;39:19–33. https://doi.org/10.1016/j.sbspro.2012.03.088

110. Fried T, Goodchild AV, Sanchez-Diaz I, Browne M. Evaluating spatial inequity in last-mile delivery: a national analysis. Int J Phys Distrib Logist Manag. 2024; [Forthcoming].

111. Verlinde S, Kin B, Strale M, Macharis C. Sustainable freight deliveries in the pedestrian zone: facilitating the necessity. In: Proceedings of the European Transport Conference; 2016. [Details such as journal or DOI not provided.]

112. Sánchez JM, Ortega E, López-Lambas ME, Martín B. Evaluation of emissions in traffic reduction and pedestrianization scenarios in Madrid. Transp Res Part D Transp Environ. 2021;100:103064. https://doi.org/10.1016/j.trd.2021.103064

113. Fried T. Electric vehicles need charging infrastructure. Is urban freight any different? (Part I) [Internet]. Goods Movement 2030 Blog; 2022 Aug 31 [cited 2025 May 20]. Available from: https://www.goodsmovement2030.com/post/charging-infrastructure-urban-freight

114. Urban Freight Lab. The final 50 feet project [Internet]. [cited 2025 May 20]. Available from: https://urbanfreightlab.com/final-50-feet/

115. Katsela K, Güneş Ş, Fried T, Goodchild A, Browne M. Defining urban freight microhubs: a case study analysis. Sustainability. 2022;14(1):532. https://doi.org/10.3390/su14010532

116. Read DC. New places and new spaces for e-commerce distribution: three strategies bringing industrial and retail real estate closer together [Internet]. NAIOP Research Foundation; 2022 Jun [cited 2025 May 20]. Available from: https://www.naiop.org/globalassets/research-and-publications/report/new-places-and-new-spaces-for-e-commerce-distribution-three-strategies-bringing-industrial-and-retail-real-estate-closer-together/researchreportnew-places-and-new-spaces-for-e-commerce-distribution-report.pdf

117. Lee & Associates. The growing need for EV charging infrastructure in industrial real estate [Internet]. 2024 Dec 4 [cited 2025 May 20]. Available from: https://www.lee-associates.com/houston/2024/12/04/the-growing-need-for-ev-charging-infrastructure-in-industrial-real-estate/

118. City of New York. Notice of adoption – Microhubs pilot program [Internet]. NYC City Record; 2025 Jan 14 [cited 2025 May 20]. Available from: https://a856-cityrecord.nyc.gov/RequestDetail/20250106003

119. Dalla Chiara G, Krutein KF, Ranjbari A, et al. Providing curb availability information to delivery drivers reduces cruising for parking. Sci Rep. 2022;12:19355. https://doi.org/10.1038/s41598-022-23987-z

120. City of Los Angeles. Zero emission delivery zones (CF 21-0147) [Internet]. Inter-departmental correspondence; 2021 Apr 28 [cited 2025 May 20]. Available from: https://clkrep.lacity.org/onlinedocs/2021/21-0147_rpt_dot.pdf

121. Portland Bureau of Transportation. Zero emission delivery zone [Internet]. [cited 2025 May 20]. Available from: https://www.portland.gov/transportation/planning/zero-emission-delivery/zero-emission-delivery-zone

122. Portland Bureau of Transportation. Interview results: carrier perspectives on delivery operations and zero-emission zones in downtown Portland [Internet]. 2024 Sep [cited 2025 May 20]. Available from: https://www.portland.gov/transportation/planning/zero-emission-delivery/documents/ufl-technical-report-carrier-interviews/download

123. Fried T, García L. Planning for equity and justice in freight. In: *Advances in Transport Policy and Planning: Freight Transport Planning*. 2024;9:173–204. doi:10.1016/bs.atpp.2024.09.001

124. Calma J. The EPA opens the door to suing warehouse owners over air pollution [Internet]. The Verge; 2024 Sep 12 [cited 2025 May 20]. Available from: https://www.theverge.com/2024/9/12/24242735/epa-warehouses-ecommerce-air-pollution-indirect-source-rule

125. South Coast Air Quality Management District. Hybrid Mobile Source Committee Meeting agenda [Internet]. 2024 Mar 15 [cited 2025 May 20]. Available from: https://www.aqmd.gov/docs/default-source/Agendas/Mobile-Source/msc-agenda-031524.pdf?sfvrsn=18

126. Calma J. What a billion square feet of warehouses looks like: e-commerce takes up a lot of space [Internet]. The Verge; 2022 May 2 [cited 2025 May 20]. Available from: https://www.theverge.com/23053387/billion-square-feet-warehouses-california-inland-empire-online-shopping

127. Illinois General Assembly. Bill status of HB5013 [Internet]. [cited 2025 May 20]. Available from: https://www.ilga.gov/legislation/BillStatus.asp?DocNum=5013&GAID=17&DocTypeID=HB&LegId=152973&SessionID=112&GA=103

128. New York State Senate. Bill A01718 amendment C (2023) [Internet]. [cited 2025 May 20]. Available from: https://www.nysenate.gov/legislation/bills/2023/A1718/amendment/C

129. New York City Council. Intro 1130-2024+ [Internet]. [cited 2025 May 20]. Available from: https://intro.nyc/1130-2024%2B?utm_source=chatgpt.com

130. South Coast Air Quality Management District. Rule 2305 – Warehouse Actions and Investments to Reduce Emissions (WAIRE) Program [Internet]. [cited 2025 May 20]. Available from: https://www.aqmd.gov/docs/default-source/planning/fbmsm-docs/waire-program-overview-factsheet.pdf

131. San Joaquin Valley Air Pollution Control District. Indirect source review: brochure [Internet]. [cited 2025 May 20]. Available from: https://ww2.valleyair.org/media/ryunzl4j/isr-brochure.pdf

132. B-Line Urban Logistics. Warehousing services [Internet]. [cited 2025 May 20]. Available from: https://b-linepdx.com/services/warehousing/

133. British Land. The benefits of logistics hubs in London [Internet]. [cited 2025 May 20]. Available from: https://www.britishland.com/news/the-benefits-of-logistics-hubs-in-london/

134. Maiden T. Prologis sees further tightening in logistics real estate supply [Internet]. FreightWaves; 2021 Jun 11 [cited 2025 May 20]. Available from: https://www.freightwaves.com/news/prologis-sees-further-tightening-in-logistics-real-estate-supply

135. Sogaris. Chapelle International logistics hub [Internet]. [cited 2025 May 20]. Available from: https://www.sogaris.fr/fiche/chapelle-international/

136. Brettmo A, Sanchez-Diaz I. Property owners as possible game changers for sustainable urban freight. Res Transp Bus Manag. 2022;45(Pt A):100745. https://doi.org/10.1016/j.rtbm.2021.100745

137. Brettmo A, Browne M. An exploratory study of the scope for receivers to influence urban freight consolidation through changes in their procurement practices [Internet]. Presented at: 21st Annual Conference of The Chartered Institute of Logistics and Transport, Logistics Research Network; 2016 [cited 2025 May 20]. Available from: https://urn.kb.se/resolve?urn=urn:nbn:se:ri:diva-73155

138. Microhub. Buildings and logistics microhubs [Internet]. [cited 2025 May 20]. Available from: https://www.microhub.com/buildings