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Solving Last Mile Transport: **A Virtual Delivery Emissions Model**

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Client: Environmental Defense Fund

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Acronyms

AQI	Air Quality Index
BAAQMD	Bay Area Air Quality Management District
CARB	California Air Resources Board
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DHL	Dalsey, Hillblom and Lynn
EDF	Environmental Defense Fund
EV	Battery Electric Vehicles
FEDEX	Federal Express
GHG	Greenhouse Gas
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
kWh	Kilowatt Hours
LA	Los Angeles
LCFS	Low Carbon Fuel Standard
MPG	Miles per Gallon
MT	Metric Ton
MWh	Megawatt Hour
NY	New York
NYTVIP	New York Truck Voucher Incentive Program
NO_X	Nitrous Oxide
ORION	On-Road Integrated Optimization and Navigation
$PM_{2.5}$	Particulate Matter
PPA	Power Purchase Agreement
SO_2	Sulphur Dioxide
TCO	Total Cost of Ownership
UFT	Urban Freight Transport
UPS	United Parcel Service
USPS	United States Postal Service
VOC	Volatile Organic Compounds

Glossary of Terms

Air Quality — The degree to which ambient air is assessed and measured with pollution indicators within a particular range, such as the amount of particulate matter, carbon monoxide, sulphur dioxide.

Brand — Reference to e-commerce companies selling products to a consumer within pure-play, direct-to-consumer, or brick and mortar retail models.

Carbon Offsets — A certificate representing the reduction of one metric ton (2,205 lbs.) of carbon dioxide emissions.[1] When an offset is purchased, it funds projects that reduce global GHG emissions. This enables emissions reductions to become a purchasable commodity.[2]

Carrier — Reference to on-the-road shipping companies who execute last mile deliveries for e-commerce companies.

Carbon Credits — A tradable permit or certificate that gives the right to the holder to emit one ton of carbon dioxide or an equivalent of another greenhouse gas.[3]

Class 4-5 Truck — A medium sized delivery vehicle typically used in urban areas that has a gross vehicle weight rating (GVWR) between 14,001 – 19,500 pounds. Sometime referred to as a Class 4-5 stepvan.[4]

Critical Mass — The minimum amount needed to produce a particular result

Congestion Pricing — A system where drivers pay a fee to enter a specific area as part of a demand management strategy to relieve traffic congestion within that zone.[5]

Direct-to-Consumer — Products sold directly to the end consumer without third-party retailers, wholesalers, or other middlemen.[6]

Dynamic Route Optimization (DRO) — Routing systems that maximize route efficiency for carriers.[7]

E-commerce — Commercial transactions for goods and services conducted electronically on the internet.

Electric Vehicle (EV) — A vehicle that uses one or more electric motors. References all categories of EVS: battery electric vehicles, plug-in hybrid electric vehicles, and hybrid electric vehicles.

Energy Supply Mix — A combination of primary energy sources (such as coal, nuclear, natural gas, wind, solar, biomass and hydro) that produce electricity.

GHG Inventory — The combined emissions of greenhouse gases in an assessment of an entity's carbon footprint; gases are classified under three direct and indirect Scopes of activity: Scope 1, Scope 2 and Scope 3.[8]

Greenhouse Gas Emissions — Gases that trap heat in the atmosphere and contribute to climate change.[9] The most prevalent GHG include carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), and Water Vapor (H_2O).[10]

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) — The California Air Resources Board program provides financial incentives to lower the cost of hybrid and zero-emission trucks and buses throughout California. Enacted to accelerate the adoption of cleaner, more efficient trucks and buses.[11]

Instant Delivery — Receiving goods and/or services purchased online within two hours-two business days of placing an order.

Last Mile Delivery — The last stage in the logistics process when goods move from a transportation hub (such as a UPS Distribution Center) to the final delivery destination, typically the home of an individual consumer.

Last Mile Fleet — The type of transportation used for the last mile delivery.

Glossary of Terms

Low Carbon Fuel Standard (LCFS) — The LCFS is a part of a comprehensive set of programs in California to cut GHG emissions and other smog-forming and toxic air pollutants by improving vehicle technology, reducing fuel consumption, and increasing transportation mobility options.[12] This creates a market for buying and selling generated credits for the use of low emitting transportation fuels.

Low-Emission Zones (LEZ) — Areas that prohibit high-emitting vehicles from entering; a regulation tactic to encourage electric vehicle adoption.

New York Truck Voucher Incentive Program (NYTVIP) — A voucher and/or discount program which allows existing fleets to implement clean vehicle technologies in New York State. This includes the lease all-electric (BEV), hydrogen fuel cell electric (FCEV) plug-in hybrid electric (PHEV), conventional hybrid electric (HEV), compressed natural gas (CNG), or propane medium- and heavy-duty vehicles (weight class 3 through 8).[13]

Power Purchase Agreement (PPA) — A long-term agreement or contract between two parties, one which generates electricity and one which is purchasing the electricity.

Pure Play — (Pure players); A business that sells products solely through e-commerce channels and has no physical store.

Rebates — Money sent back to the customer upon them paying full price for the product; a tactic for incentivizing or promoting a product.

Renewable Energy Certificate (REC) — A market-based instrument that represents the property rights to the environmental, social and other non-power attributes of renewable energy generation. RECs are issued when one megawatt hour (MWh) of electricity is generated and delivered to the electricity grid from a renewable energy source.[14]

Scope 1 Emissions — Emissions from sources that are owned or controlled by the company.[15]

Scope 2 Emissions — Indirect emissions from sources that are owned or controlled by the company.[16]

Scope 3 Emissions — Emissions from sources not owned or directly controlled but related to the company's activities.[17]

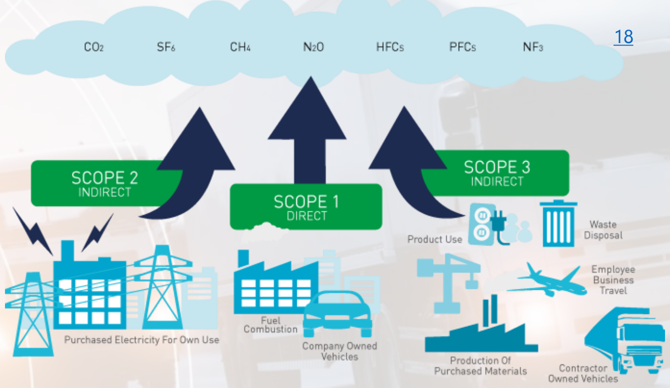

Figure 1: Overview of Scope 1, 2, and 3 Emissions

Science-Based Targets — Goals developed by a company consisting of distinct guidelines to reduce greenhouse gas emissions. It is a science-based target if it has been developed with the scale of reductions required to keep global warming well below 2°C from pre-industrial levels.[19]

Smart Grid — A combination of an electricity supply network and a set of digital communications technology that can detect and react to local changes like leakages in usage.

Total Cost of Ownership (TCO) — The purchase price of an asset and its operating costs over the asset's lifespan.

Executive Summary

Background: In 2019, global e-commerce sales were expected to hit nearly $3.46 trillion U.S. dollars.[20] The growing global e-commerce industry is demanding faster delivery and increasing the number of delivery vehicles on the road. Most short-haul deliveries, referred to as last mile delivery, are made by medium and heavy-duty vehicles. These vehicles are typically diesel-fueled, internal combustion engines that are known to impact local air pollution and contribute to greenhouse gas (GHG) emissions.

Air pollution has severe social, economic and health impacts around the world, outlined in Figure 2.

133.9 MILLION Americans live with unhealthy air

There are as many as **5 MILLION PREMATURE DEATHS** each year from air pollution

Research suggests that air pollution can **IMPACT STOCK MARKET PERFORMANCE**

Figure 2: Air Pollution Impacts [21]

Objective: As pressure for environmental accountability heightens, brands are looking for ways to further reduce their carbon emissions and improve air quality. Many of the remaining emissions reduction opportunities exist in brands' Scope 3 footprint. These are indirect emissions from sources not owned or directly controlled, but are related to the company's activities. The Environmental Defense Fund tasked Columbia University's Sustainability Management Graduate Program to develop a model that would allow brands' to account for and reduce their emissions to improve air quality through zero-emissions delivery within the last mile.

Methodology: Best practices by key stakeholders in international and domestic arenas for reducing emissions in last mile delivery were researched and analyzed (See Appendix 1). Per EDF's direction, the focus of the solutions suggested in this report was on the adoption of EVs. After identifying common solutions and incentives across each stakeholder group, a Maturity Framework was built, which helped develop the criteria for the Virtual Delivery Emissions Model.

Overview of the Model: The Virtual Delivery Emissions Model will help the brands calculate potential improvements to air quality and GHG emissions reductions' by determining the number of miles an EV delivery truck is driven in place of a diesel truck during last mile delivery.

(i) The proposed Virtual Delivery Emission Model enlists the benefits for brands and carriers through the co-financing of EVs including emissions reductions, air quality improvements, and reduced financing costs for both parties.

(ii) By implementing the Virtual Delivery Emissions Model, a brand or group of brands, will be able to establish a long-term agreement with a carrier and account for reductions in their Scope 3 emissions.

(iii) Carriers will be able to reduce their Scope 1 emissions by partnering with the brands in the proposed model.

(iv) Deployment of EVs within the last mile delivery will result in Scope 1 emission reductions for cities.

The model puts forward two co-financing structures for the brand(s) and a carrier to scale the use of EVs for last mile delivery, either through a power purchase agreement or lease-based structure.

The model focuses on GHG emissions from Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFC), and Carbon Dioxide (CO_2). These emissions have been specified in terms of Carbon Dioxide equivalent (CO_2e). For air quality improvements, the model uses data from the EPA to aggregate the benefit in metric tons of Particulate Matter 2.5 ($PM_{2.5}$), Nitrous Oxide (NO_x), Carbon Monoxide (CO), and Volatile Organic Compounds (VOC).

Through a power purchase agreement, brand(s) will contract with carrier(s) to pay them on a dollar-per-pound basis for every package delivered using an EV. The lease-based approach relies on a third-party to lease an EV delivery fleet with a flat monthly fee for brands.

Los Angeles and New York City were chosen as the pilot cities to evaluate financial savings, potential emissions reductions, and air quality improvement using the Virtual Delivery Emissions Model.

Executive Summary

Findings: Brands and carriers can reduce capital expenses and emissions through either of the proposed co-financing structures for EV delivery in the last mile.

Carriers can reduce their annual maintenance costs by almost half and lower their annual average fuel costs when switching to EVs across both cities. State, Federal, and utility sponsored incentives are crucial for cost-effective EV adoption. These incentives alleviate total cost of ownership and operating expenses. Los Angeles was found to be economically favorable to implementing the PPA financing structure (Model A). This is because of available subsidies that support the financial viability of adopting the model compared to New York. For every package delivered using Model A: PPA, a brand or group of brands could save $0.11 per pound in L.A. when their carrier uses an EV for last mile delivery. For New York City, brands would pay $0.04 more per pound for EV delivery, due to limited incentives offered. A cost analysis for an EV truck in both cities can be seen in Figure 3.

Using our model for a comparative study between Los Angeles and New York City, the projected emissions reduction from switching to EVs for last mile delivery for both cities is between 69 to 74 percent.

	Los Angeles, California	New York, New York
Total Cost of Ownership EV Delivery Truck	$172,488	$182,078
Cost/lbs./year	$1.12	$1.18
Total Cost of Ownership Diesel Delivery Truck	$184,674	$170,700
Cost/lbs./year	$1.23	$1.14
Savings to Brand ($/lbs.)	**$0.11**	**($0.04)**

Figure 3: Cost Analysis for EV truck in Los Angeles and New York City

Improving air quality is a necessary and feasible benefit of EV adoption for last mile delivery. Using data from the EPA,[22] we calculated the individual reduction of an EV annually and found 0.078 MT of air quality pollutants ($PM_{2.5}$,NO_x,CO and VOC) and a dollar-per-ton value of $68,103. Our assumed critical mass is 1 MT of $PM_{2.5}$ and NOx annually, which can be met through replacing 13 diesel trucks with 13 EV trucks. Reaching this critical mass point has the potential to improve air quality, particularly in low-income neighborhoods, such as the Bronx in New York City or Wilmington in Los Angeles, where daily delivery trucks are abundant.

Recommendations:

Adoption of EVs for last mile deliveries is necessary to reduce emissions and improve air quality. The model proposed in this report requires a brand, or group of brands, to evaluate available monetary and non-monetary incentives available in the location where the EVs will be purchased and operated.

Using the Virtual Delivery Emissions Model, our estimated reduction is between 11 – 12 MT of CO_2e emissions through the replacement of a diesel truck with an EV, depending on the city. We recommend the adoption of 13 EVs for last mile deliveries in order to reduce 163 MT of CO_2e emissions in LA and 152 MT of CO_2e emissions in NYC, and improve air quality by 1 MT annually. A group of brands should work with a carrier to implement a rate structure into their pricing terms where delivery via an EV will be charged for a specified dollar amount per pound of packages.

Further research should be conducted to identify facilities that could host and charge EVs, current source of energy at identified facilities, optimal EV charging patterns, electricity service at facilities, charging infrastructure costs, and additional financial incentives for Los Angeles and New York City. Other strategies within the last mile delivery emissions reduction include parcel lockers, low emission zones, crowd sourcing, advancement and availability of market-ready technology and climate targets. EV adoption in this space will help cities and states comply with growing environmental regulations in the United States[23].

About the Client: Environmental Defense Fund (edf.org), a leading international nonprofit organization, creates transformational solutions to the most serious environmental problems. EDF links science, economics, law and innovative private-sector partnerships.

Introduction

Background

Worldwide, retail e-commerce sales, including products and services, are estimated to reach US$6.5 trillion by 2023.[24] In 2019, United States retail e-commerce sales reached upwards of $600 billion dollars, with e-commerce becoming a greater share of sales for traditional brick and mortar retail companies, representing nearly 16% of total retail sales.[25] This was the largest share of U.S. retail sales to date, fueled primarily by Amazon, which represented an estimated 36.9%.[26] With approximately 2.1 billion people purchasing goods online, retail e-commerce sales will account for 20% of the global share by 2023.[27]

As online shopping continues to grow, e-commerce is making up a larger share of spending across direct-to-consumer brands, marketplaces, and pure-play e-commerce businesses. Brands are working quickly to update their supply chain and enhance omnichannel delivery to include real-time inventory visibility, smart operations like augmented reality, and an agile distribution network to compete with pressure from Amazon and meet consumer demands for faster delivery.[28]

E-commerce players, referenced here as “brands”, are integrating new practices to meet shipping demand in a highly competitive space; however, there is a reliance on third-party carriers to provide a reliable distribution ecosystem. There are four traditional e-commerce business models; Direct to Consumer (D2C), Business to Business (B2B), Consumer to Business (C2B), and Consumer to Consumer (C2C).[29] D2C is the most commonly used business model, which is when a product or service is sold directly to the end user, in this case, a consumer. C2C, which can be referred to as a marketplace, enables a consumer to buy and sell on one platform, such as eBay or Etsy. Businesses that utilize e-commerce platforms but do not have any physical store locations, such as Fresh Direct, are known as pure play business models and are becoming more common.

Context: Last Mile Delivery and Urban Air Pollutions

Most e-commerce deliveries are made on fossil-fuel intensive box trucks, vans, and cars. A 2015 research study conducted by the World Health Organization highlighted a direct correlation between air pollution and a wide range of public health concerns.[30] In a 2016 World Resource Institute (WRI) study, transport emissions — which primarily involve road, rail, air, and marine transportation — accounted for over 24% of global CO_2 emissions.[31] As a large contributor to the share of last mile deliveries, brands have a responsibility to tackle their Scope 3 emissions.

Greenhouse gas emissions created by the current last mile delivery ecosystem continue to be a challenge for cities and localities around the world in effectively combating poor air quality and achieving climate goals. By 2050, 89% of the U.S. population is estimated to live in urban areas.[32] The expected growth in the urban population, thriving e-commerce marketplace, and an increasing demand for same-day deliveries has made the current last mile delivery system inefficient and environmentally damaging. The externalities of these new pressures produced by the rise of e-commerce deliveries require a review of downstream processes among all e-commerce brands and carriers of these products and services. Last mile delivery models and their associated emissions and air quality impacts within urban areas must be addressed.

Project Goal and Scope

The Capstone Project team developed a “Virtual Delivery Emissions Model” as a tool for brands to reduce their Scope 3 emissions and improve air quality through financing EVs for last mile deliveries. This tool will help brands understand potential air quality improvement, various emissions reduction opportunities, their costs, their financing needs, and their contracting needs with carriers. This model will assist brands 1) Measure their current GHG emissions from last mile delivery; 2) Quantify emissions reduction opportunities using electric fleets; 3) Provide a quantification for how EVs can mitigate those emissions; 4) Understand potential financing mechanisms that will help fund their transition to EV fleets.

Methodology

Phase 1: Research & Define Stakeholders

The team researched best practices across the EV and last mile delivery space; identifying brands, carriers and cities as the key stakeholders.

Brands: As this model is a tool for a brand or group of brands with an e-commerce channel, the team researched criteria (Appendix 2) and identified brands that are publicly discussing their last mile footprint. Brand profiles were created for retail giants Amazon, Walmart, and Target to review their sustainability framework. Only a few companies are actively pursuing EV deployment themselves or through a third-party (e.g. ASOS UK partnership with London's electric delivery fleet Gnewt). Last mile delivery emissions for brands is an emerging topic of research.

Carriers: Carriers fulfill most last mile delivery logistics' needs and are directly responsible for transporting packages from the nearest shipping hub to the final destination. Carriers are taking various approaches and investments in the EV space for last mile delivery. FedEx and UPS are the top two partners for brands to accelerate the deployment of EV fleets within the United States (reference Appendix 3-6). They both have robust corporate sustainability reports, stringent emissions reduction goals, and current investment in last mile delivery mitigation through the deployment of EV fleets. DHL ranked high for their investment in electric scooters and DRO; however, USPS did not meet our criteria outlined in Appendix 4.

Cities: The team curated a list of international cities that are leading emissions reductions and improving air quality through various last mile solutions, including low emission zones and congestion tax (Appendix 7). Our focus was on the deployment of EVs for last mile delivery within the United States. By analyzing policies, incentives, presence of EVs, infrastructure, energy supply mix, and financing mechanisms of various U.S. cities, the team gained a critical understanding of how cities are creating ideal conditions for EV market penetration. A critical finding was the correlation between EV penetration and the availability of financial incentives.[33]

Phase 2: Maturity Framework

For the second phase, the team developed a maturity framework to identify the main enablers and tools necessary for the growth of EV deployment in last mile delivery (Appendix 8). The team focused on identifying common solutions and incentives across each stakeholder group. This framework constructed the foundation of the Virtual Delivery Emissions Model.

The maturity framework provides a "high, medium, and low" set of criteria for a brand or group of brands to evaluate a city or carrier and determine their EV readiness. The following criteria are critical to developing, implementing, and scaling EV last mile strategies:

Brands: Brand equity (corporate sustainability report, offsets, and/or a science-based target); emissions tracking system; and, last mile mapping

Carriers: Active EV strategy; last mile mapping; emissions tracking system; corporate sustainability goal; capital allocation for EV and EV infrastructure

Cities: Presence of EV infrastructure; presence of state and local financial incentives; energy supply mix; emission tracking systems; and, equity (such as reduction goals set by cities).[34] Presence of utility interest, incentives , rebates, and/or grants for charging infrastructure, electricity service upgrades, or rate design to encourage the adoption of EVs and supply equipment

The following criteria should be reviewed by respective stakeholders as these were not within the Scope for this capstone project and are noted for consideration:

Brands: Existing capital dollars for EVs

Carriers: Existing EV infrastructure

Cities: Air quality indicators, local air quality monitoring, financial disincentives and local policies

Methodology

Phase 3: Model Development

The Virtual Delivery Emissions Model provides a structure for a brand or group of brands to finance EVs for the use of last mile delivery to reduce their annual Scope 3 emissions from transportation and improve air quality. The model allows the brand(s) to calculate the costs and emissions reductions for switching to EVs through a carrier partnership for last mile delivery. Model guidelines are outlined in Appendix 9. A brand or group of brands can work with a carrier to use the model by inputting the total distance (in miles) a last mile diesel truck drives annually and receive a quantification of last mile delivery emissions that would be saved by switching to an EV. The model could benefit carrier's Scope 1 reduction targets, and cities strategy to mitigate air pollution, improve air quality, and support their climate mitigation targets.

To develop the model, the team looked at the average amount of miles a diesel delivery truck in the U.S. travels in a year for last mile delivery to determine emissions from a single diesel delivery truck. The calculated emissions are in metric tons of carbon dioxide equivalent (Mt/CO_2e) and are based on the number of gallons of diesel consumed per delivery truck, annually. This was calculated by using the average miles driven by a last mile delivery truck and the average fuel economy of that truck. Using data from the EPA, we aggregated the benefit to air quality in metric tons of CO, NO_x, VOC, and $PM_{2.5}$.

To determine the emissions savings, the Mt/CO_2e and Mt/NOx and SO_2 were calculated for EVs using the same average mileage as diesel trucks. To convert mileage into metric tons, the team found the average electricity (kWh) consumed per mile for EVs. Assuming the EV trucks make deliveries during the day and charge overnight, the emission rates for the average generation mix of each subregions were used. Thereby avoiding on-peak energy, peak demand charges, and consuming baseload generation.

Depending on the amount a brand wishes to reduce, the model provides two co-financing opportunities which can incentivize carriers to finance EV deliveries, and a third consideration.

Model A: Power Purchase Agreement (PPA) Model

This structure is based on a typical power purchase agreement, commonly found in the solar energy industry. In a community solar PPA, a customer enters into a subscription for the amount of energy specific solar panels produced at a different location. The customer receives a credit on their energy bill by getting charged a lower rate for that energy than the utility. This type of contract is appealing because many fleet operators are hesitant to purchase EVs due to their high startup costs and complicated charging infrastructure.[35] By utilizing the PPA Model, the brand(s) can contract with carriers to pay them on a dollar-per-pound basis for every package that is delivered by the EV.

Model B: Lease-Based Model

A leasing model which was inspired by a recent trend in which some carriers, such as FedEx, are using third-party companies to lease EVs.[36] This minimizes the upfront capital necessary for carriers to electrify their fleets. In this model, the brand(s) agree to pay a monthly flat fee to lease the carriers EVs.

Model C: Purchase of EVs (Consideration)

If a brand, or a coalition of brands, have the financial resources, a third alternative model would be to purchase an EV fleet and install the necessary infrastructure at distribution centers. While plug-in EVs are likely to remain more costly than internal combustion vehicles until the price of lithium-ion batteries decreases.[37] The brand(s) could deploy a company fleet to ensure that their products are being delivered on EVs and claim the emissions reductions that come with that. Based on stakeholder interviews conducted for this report (Appendix 13), a PPA or a leasing model were the preferred models. Due to the need for large upfront capital and logistical capacity, there is little interest from brands to purchase EVs.

Methodology

Phase 4: Pilot City Selection

To quantify the impact and recommend a feasible Virtual Delivery Emissions Model for last mile delivery, we measured select major U.S. cities' levels of traffic congestion, population density, air quality measures, and the defined criteria discussed in Methodology Phase 2. The team mapped out six potential cities (Figure 4) that would be best equipped to pilot our Model given their initiatives around EV deployment,[38] infrastructure, and incentives from a local, state, and utility standpoint. The team selected Los Angeles, California, as it has multiple favorable incentives for EV penetration and suffers from poor air quality relative to other U.S. cities. At the request of our client, New York City was added for a cost analysis and comparison among the two major cities. Both cities exhibit high population density, demonstrate strong retail sales, offer various EV incentives, and have set carbon reduction goals as outlined in Figure 5.

Potential City	EV Penetration (ranking)	Incentives	Energy Supply	Population Density (per sq. mile)	Equity & Emissions Tracking	Air Quality Indicator
New York, New York	**-**	**12**	**29% Renewable**	**27,016**	**Yes**	**38**
Bay Area (includes SF, SJ and Oakland), California	#1	40	Bay Average 35% renewable	San Fran: 17,246 San Jose: 5,803 Berkley: 11,614	Yes	40
Portland, Oregon	#7	3	27% Hydro	4,740	Yes	20
Seattle, Washington	#2	7	88% Hydro-Electric	7,692	Yes	25
Los Angeles, California	**#6**	**40+**	**30% renewable**	**8515**	**Yes**	**35**
Houston, Texas	-	12	13%	3,662	Yes	48

Figure 4: Mapping Six U.S. Cities for EV Readiness

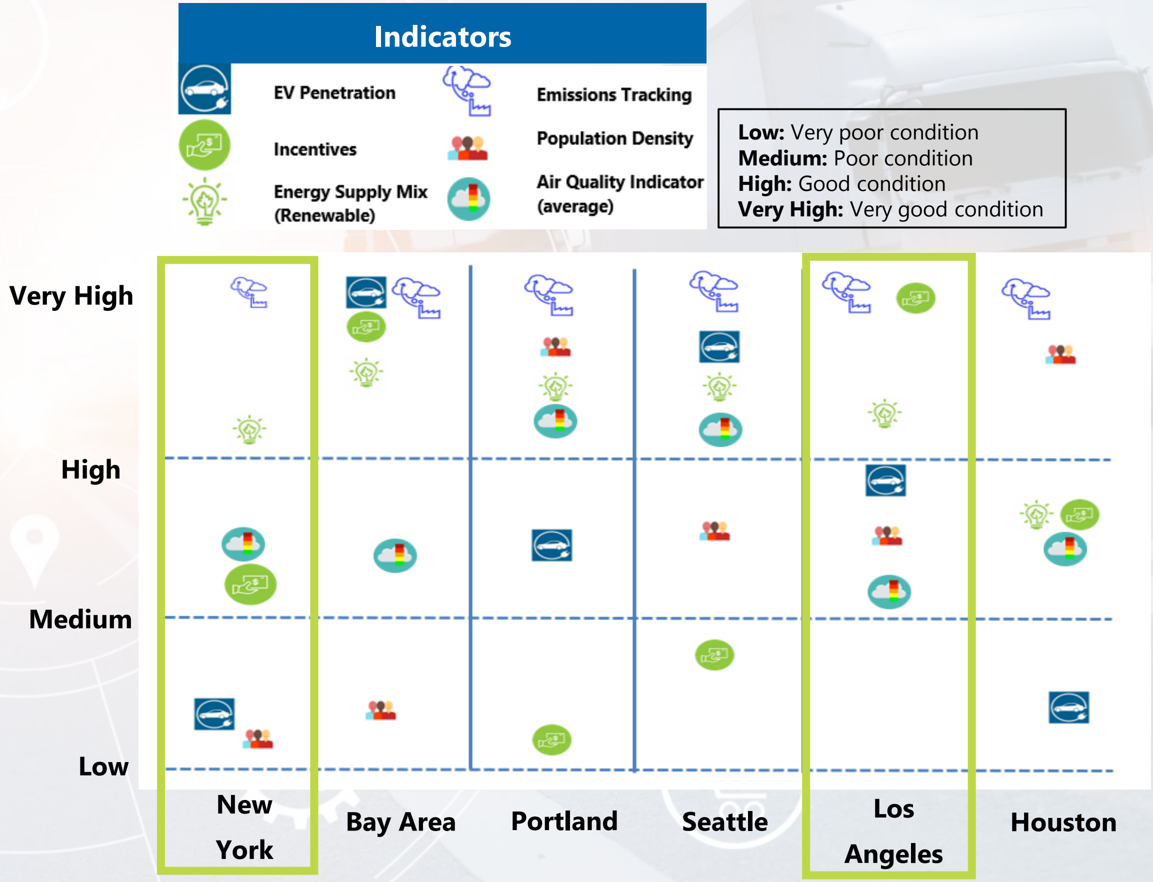

Figure 5: Pilot City Attribution Exercise
Includes Figure 4 values

Chapter 1: The Virtual Delivery Emissions Model

Chapter 1: The Virtual Delivery Emissions Model

The Virtual Delivery Emissions Model is a tool for a brand or group of brands to calculate the costs and emissions reductions by co-financing EVs in partnership with a carrier, for use of last mile delivery. The model allows brands to calculate their annual Scope 3 emissions reductions from transportation and work towards improving air quality. For this report, the team modeled two co-financing scenarios in Los Angeles and New York. Based on our model, the projected emissions reduction from switching to EVs for last mile delivery is roughly 74 percent for Los Angeles and 69 percent in New York. The model guidelines and resources are found in Appendix 9.

Emissions from Truck-Load

The model calculates emissions from a diesel Class 4-5 truck with a Gross Vehicle Weight Rating between 14,001 – 19,500 lbs. To calculate the emissions, the model assumes a delivery truck travels 13,116 miles per year and operates for 300 days per year.[39] The empty vehicle weight capacity of a Class 4-5 truck can be up to 10,000 lbs.,[40] the model assumes 500 lbs., or 5% of the vehicle, of packages are shipped on average each day.

To calculate emissions, brand(s) and carrier can input their unique delivery data into our model for miles driven by a last mile delivery truck. Based on the NGO Stringency Target Assumptions provided by EDF, the average fuel economy for a vocational vehicle similar to a Class 4-5 truck is 10 miles per gallon and consume roughly 1,311.6 gallons per year. The tailpipe emissions factor per gallon of diesel in kg of CO2/gallon is 10.39 and the upstream emissions factor for generation of diesel in kg of CO_2/gal is 2.47.[41] This results in 16.87 metric tons of CO_2e emitted per diesel truck, annually; refer to LA reduction Figure 6.

To calculate the emissions produced from an EV, the same number of miles and operating days used above were applied. To convert miles to emissions, a kWh/mile conversion rate that accounts for the electricity used to charge EVs was applied. The average kWh/mile is 1.4.[42] The assumed EV is expected to drive 13,116 miles per year, which equates to 19.24 MWh, annually (taking into account energy losses of 4.8%[43] in CA). The emissions factor for one MWh of electricity generated in California is 498.7 pounds of CO_2e,[44] which equates to 4.35 metric tons of CO_2e.

Assumptions	
Average Distance of Last-Mile Delivery Each Year	13,116.00
Miles per day	43.72
Operating Days Per Year	300.00
Diesel Truck	
Miles per Gallon of Delivery Truck	10.00
Total Gallons Consumed Per Year (Diesel)	1,311.60
Upstream Emissions per Gallon of Diesel Generation (kg of CO2/gal)	2.47
Tail Pipe Emissions per Gallon of Diesel (kg of CO2/gal)	10.39
Total Emissions Per Year (kg of CO2)	16,867.18
Total Emissions Per Year (Metric Tons CO_2e)	**16.87**
Total Emissions Per Year (kg of CO, NOx, VOC, and $PM_{2.5}$)	78.46
Total Emissions Per Year (Metric Tons CO,NOx, VOC, $PM_{2.5}$)	**0.078**
Electric Vehicle Truck	
Average kWh/Mile	1.4
Total kWh Per Year	18,362.40
Total MWH Per Year	18.36
Total MWH Per Year (with Grid Losses)	19.24
Total Output Emissions CAMX Subregion (lbs. of CO2/MWH)	498.7
Tail Pipe Emissions (lbs. of CO2/MWH)	-
Total Output Emissions Per Year (lbs. of CO2)	9,596.88
Total Output Emissions Per Year (kg of CO2)	4,353.07
Total Output Emissions Per Year (Metric Tons of CO_2e)	**4.35**
Total Emissions Per Year (kg of NOx, SO2)	4.45
Total Emissions Per Year (MT of NOx, SO_2)	0.0045

Figure 6: Emissions Reduction from EV in Los Angeles

Review Model Here

Chapter 1: The Virtual Delivery Emissions Model

Model A: Power Purchase Agreement (PPA)

The first model created is a Power Purchase Agreement (PPA) for the brand(s) and carriers to finance EVs for last mile deliveries. In comparing this model to a PPA in the solar industry, the brand(s) become the customers and the carrier is the supplier. The carrier agrees to finance and operate EVs and receive their return on investment by charging brand(s) for each pound of package that is delivered on that EV. The brand(s) could be eligible to receive a monthly credit on their bill from a carrier, like a community solar PPA. This can be used to offset the brand(s) costs incurred from shipping packages around the country.

This model allows for the brand(s) to avoid upfront costs when deploying EVs, as the vehicles are owned and operated by the carrier. The brand(s) are not responsible for loans, long-term maintenance, or fuel/electricity costs. In a similar way to how the brand is currently charged by their carriers (e.g., rates based on weight of package), the brand(s) should work with a carrier to implement a rate structure into their pricing terms where delivery via an EV will be charged for a specified dollar amount per pound of packages. The brand(s) would pay a locked-in price ($/lbs. of packages delivered) that can be contracted for the long-term to avoid rate changes. The model guidelines and are found in Appendix 9.

To calculate how the brand(s) can finance or incentivize the carrier to use EVs for last mile delivery, we needed to understand the Total Cost of Ownership (TCO) of diesel and electric trucks. The TCO represents the upfront capital needed for the carrier to acquire, operate, and maintain these trucks and their associated infrastructure. Due to the available city and state incentives for EVs, the TCO for Los Angeles and New York is different (see Chapter 2). To determine the difference in cost between diesel and EV, the battery-electric and diesel Class 4-5 walk-in truck is used as the vehicle type because of their common use in last mile delivery transportation. The TCO was calculated for both trucks, which provided the basis for the cost-per-pound charge calculated for each type of vehicle.

A disadvantage of this model is the residual value of the vehicle is owned by the carrier and not the brand(s). The model assumes the carrier is willing to take on more risk in financing the purchase of EVs (i.e., value for money in its service-delivery business plan) in an area that may not have tax incentives to ensure the cost-effectiveness of EV trucks.

Model A (PPA): Savings from a coalition of brands

Brand(s) will pay their share of the PPA total cost annually. If there are more brands in a coalition, it will lower the individual cost and contribution to the pounds of packages shipped by a single EV. Based on our calculations and assumptions previously mentioned, we estimate a PPA rate of $1.12/lbs. in Los Angeles and $1.18/lbs. in New York, which is detailed on the next page.

Figure 7 breaks down the total cost for an individual brand or coalition of brands. In our example, if there are four brands included in the PPA Model and the contributions are split evenly among each, then each brand will be responsible for 37,500 lbs. of packages shipped by the EV annually. This would equate to $42,000 in LA, based on our $1.12/lbs. rate, and $44,250 in NYC, based on our $1.18/lbs. rate. This assumes 150,000 pounds of packages are shipped by the EV. The number of EVs needed decreases with fewer pounds shipped based on an average weight limit of Class 4-5 truck. While critical mass will be different for each brand's supply chain costs, an inflection point is reached once 10 brands join the coalition as the PPA contribution cost decreases by about 90 percent. One challenge will be the data accounting and how each brand will be credited for the emissions reduction, which is outside the scope of this report.

Brands in Coalition	Packages (lbs.) shipped by EVs per year	**# of EVs needed for shipping the packages**	Los Angeles: Total cost of yearly PPA contribution Rate: $1.12/lbs.	New York: Total cost of yearly PPA contribution Rate: $1.18/lbs.
1	150,000	**9**	$167,488	$177,078
4	37,500	**2**	$41,872	$44,270
10	15,000	**1**	$16,749	$17,708
20	7,500	**1**	$8,374	$8,854
30	5,000	**1**	$5,583	$5,903

Figure 7: Total Cost for Brand or Group of Brands in LA and NYC for Model A: PPA

Figures rounded to the nearest whole number

Chapter 1: The Virtual Delivery Emissions Model

In Los Angeles, the cost-per-pound for the shipment of packages is cheaper with an EV than a diesel truck in New York City, due to limited incentives. The brand(s) would need to contribute more upfront capital in New York City to incentivize the carrier to electrify. The cost difference is a result of differences in the Total Cost of Ownership in California and New York. As mentioned, California reduces costs by switching to an EV (Figure 8); whereas New York would see increase costs by making the switch to EV (Figure 9). With a PPA rate of $1.12/lbs. in LA, this option would be financially appealing to carriers after 150,000 lbs. of packages have been shipped, annually. Using the same NGO Stringency Target Assumptions, the TCO calculations are the sum of discounted cash flows for an assumed 12-year vehicle life using a five percent discount rate. These same assumptions were used on the California Air Resources Board Advanced Clean Trucks Total Cost of Ownership Discussion Document[45] to compare the TCO of an EV to a diesel truck.

Total Cost of Ownership of Truck (LA) Assumptions	Battery-Electric	Diesel
Miles per day	43.72	43.72
Operating Days Per Year	300	300
Miles Driven Per Year	13,116	13,116
Total Weight of Packages Per Year (lbs.)	150,000	150,000
Vehicle Purchase Cost (Including Taxes)	$202,211	$64,350
Hybrid and Zero Emission Truck and Bus Voucher Incentive Project (HVIP)	-$90,000	$0
Upfront Vehicle Capital Cost (Inclusive of Incentives)	$112,211	$64,350
Average Fuel Cost	$0.17/kWh	$3.74/Gal
Fuel Economy	1.4/kWh	7.4 mpg
Average LCFS Revenue ($/MT)	$134	$0
Total LCFS Revenue	-$23,484	$0
Total Fuel Cost + LCFS Revenue	$17,273	$69,592
Maintenance Cost ($/Mile)	$0.17	$0.31
Total Lifetime Maintenance Cost	$26,647	$50,732
EV Infrastructure	$16,357	$0
EV Charging Infrastructure Rebate	-$5,000	
Total	**$167,488**	**$184,674**
Cost/lbs./year	**$1.12**	**$1.23**
Savings to Brand ($/lbs.)	**$0.115**	

Figure 8: PPA Model For Cost Per lbs. of Last Mile Delivery, Los Angeles
(Model Available Here)

Total Cost of Ownership of Truck (NY) Assumptions	Battery-Electric	Diesel
Miles per day	43.72	43.72
Operating Days Per Year	300	300
Miles Driven Per Year	13,116	13,116
Total Weight of Packages (lbs.)	150,000	150,000
Vehicle Purchase Cost (Including Taxes)	$202,211	$64,350
New York Truck Voucher Incentive Project (HVIP)	-$110,000	$0
Upfront Vehicle Capital Cost (Inclusive of Incentives)	$92,211	$64,350
Average Fuel Cost	$0.21/kWh	$3.285/Gal
Fuel Economy	1.4/kWh	7.4 mpg
Average LCFS Revenue ($/MT)	$0	$0
Total LCFS Revenue	$0	$0
Total Fuel Cost + LCFS Revenue	$46,863	$55,618
Maintenance Cost ($/Mile)	$0.17	$0.31
Total Lifetime Maintenance Cost	$26,647	$50,732
EV Infrastructure	$16,357	$0
EV Charging Infrastructure Rebate	-$5,000	
Total	**$177,078**	**$170,700**
Cost/lbs./year	**$1.18**	**$1.14**
Savings to Brand ($/lbs.)	**-$0.04**	

Figure 9: PPA Model For Cost Per lbs. of Last Mile Delivery, New York
(Model Available Here)

Model B: Lease-based

The second model is a lease-based structure that is only available in Los Angeles according to Ryder, a U.S. established provider of EV fleet rental and lease trucks. This is due to the EV incentives available in CA such as the Hybrid Zero-Emission Truck, Bus Voucher Incentives Project (HVIP), and the Low Carbon Fuel Standard (LCFS) incentives. According to a sales representative at Ryder,[46] the carrier can lease one EV for an estimated monthly payment of $1,090 for a seven-year term. With the same discount rate of five percent used in the PPA Model, the brand(s) would have net present value (NPV) of $75,685, detailed in Figure 10 below:

Estimated Monthly Payment for 7 Year Lease Term ($/Vehicle)	$1,090
LCFS Credit ($/MT)	$150
Distance (Miles)	13,116
Discount Rate	5.00%
Yearly cost to brand	$13,080
NPV (7 Years)	$75,686

Figure 10: Lease-Based Model in Los Angeles

To make this payment, the brand(s) agrees to provide monthly lease payments to the carrier, who then contracts with an EV fleet provider. The added benefits to this type of agreement is the brand(s) and carriers can be more certain of their future cash flows. The lease agreement allows a carrier to use EVs without lofty upfront capital and significantly reduces operation and maintenance costs.

Model B requires a higher investment for the brand(s) because they are providing the upfront capital and a monthly lease payment to the carrier. The carrier becomes the acting operations and logistics provider for last mile deliveries (O&M contract). The carrier is expected to lease and operate the EVs; the brand(s) must turn to creditors (i.e., debt financing) to finance the project if they do not have the capital to allocate (i.e., equity financing). Weighing this choice will depend on the brands' debt-to-equity ratio. Increasing leverage comes with risks and expenses from interest costs and debt that should be evaluated before choosing this model. In contrast to the PPA model, this structure allows the brand(s) to deduct the interest paid on their debt when leasing EVs.

The disadvantage to this structure is it requires the brand(s) to insure the EVs, which would raise the costs. Additionally, the depreciation tax deduction and investment tax credit cannot be exercised.[47]

Alternatively, instead of a loan agreement with a debt provider, we propose that a coalition of brands is formed whereby each brand's respective available capital is pooled together to reduce the total cost of equity needed for the EVs. This requires coordination among e-Commerce businesses and management by a central team. A pooled credit arrangement reduces the need for borrowed capital (e.g., a bank loan) that can have undesirable high-interest rates. There is considerable liability risk to this structure, since one company could pull out of the lease agreement and impact the solvency of the group.

Under a coalition of brands, each brand contributes a share of the monthly lease payments for a seven-year lease term ($/vehicle). Additional EVs are assumed to be required after ten or more brands are in the coalition when considering the increased number of packages to be delivered. As illustrated in Figure 11, an estimated additional two vehicles are added per additional ten brands in the coalition. More information from the carrier is needed to make accurate estimates of the number of EVs for total number and weight of packages.

The annual lease cost and NPV decreases as the number of brands increases. For every ten brands added, two EVs are added, which balances the cost against the additional brands contributions. As a result, the cost contribution to the lease does not exceed $2,616 or $15,137 in NPV of future lease payments. With each additional EV, an estimate for the emission savings has been included to illustrate the reduction to a contract with a greater number of EVs deployed.

Brands in the coalition	EVs	Annual Lease cost	NPV ($) of future lease payments on the coalition-carrier contract over 7 years	Diesel-to-EV emissions offset (Mt/CO2) per year
1	1	$13,080	$75,686	12.51
4	1	$3,270	$18,921	12.51
10	2	$2,616	$15,137	25.02
20	4	$2,616	$15,137	50.04
30	6	$2,616	$15,137	75.06

Figure 11: Economic Benefits of A Brand Coalition

(Figures rounded to the nearest whole number).

Chapter 1: The Virtual Delivery Emissions Model

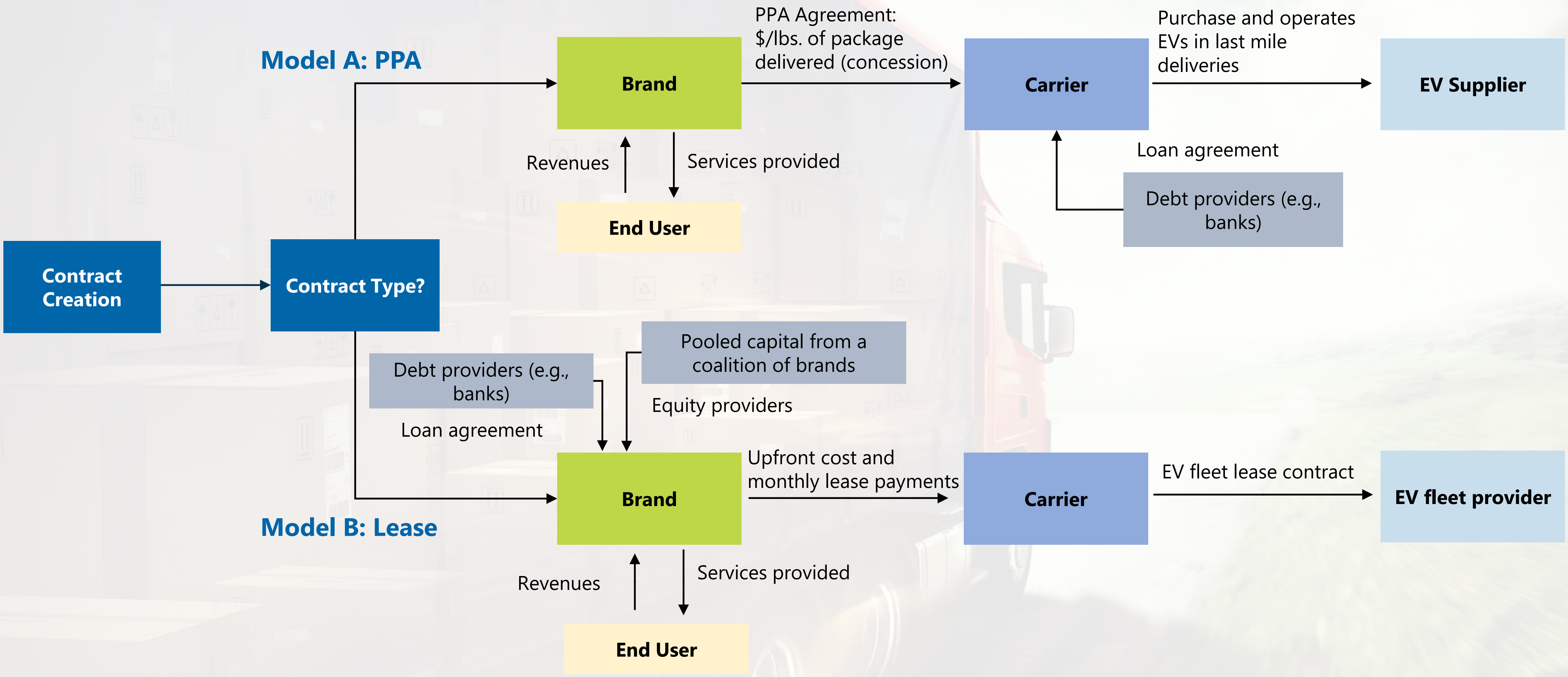

Figure 12: Capital Flow Chart for Model A and Model B

Chapter 1: The Virtual Delivery Emissions Model

Challenges and Considerations

- A common barrier to scaling corporate EV fleets is the lack of on-site charging infrastructure and available electrical service to power multiple EVs, which hinders third-party carriers from wider electrification of delivery vehicles. According to a 2018 study by GreenBiz and commissioned by UPS, over 90 percent of large organizations are not well equipped with onsite EV charging infrastructure for commercial vehicles.[48] Other notable barriers include the prohibitive purchasing cost of EVs and lack of available product in the United States.
- The presence of state incentives for reducing the TCO of EVs in California makes the purchase more financially viable. Few other states, including New York, have the same extent of incentives as California. The purchase of EVs may not be economically favorable in states that do not offer programs to lower upfront costs; this could hinder initial willingness to participate and the scaling of the proposed models.
- The lease model asks for a coalition of brands to pool their capital for a reduced outright purchase of an EV fleet. While debt providers, such as a bank, can support the project through a loan or other financing agreements, a coalition of brands allows for reduced overall project costs and improves willingness to participate. Galvanizing competing e-Commerce companies to form a joint-initiative for reducing last mile delivery emissions may come with several hurdles regarding contest and lack of interest in a long-term commitment that a PPA financing structure and an EV fleet lease agreement often require.
- When engaging with the proposed financing structures, carriers may face several deterrents. Loan interest and processing fees from a lease for an EV fleet that a carrier takes on will add additional cost to the purchase, as well as require a long-term commitment which they may not want to be constrained by. Few EV vendors may be available where the project is sought to be established, and if a vendor is locally available, the costs are variable. The carrier is expected to incur the technology and value at risk to the purchase/lease of the EVs. These are considerations the carrier will make when assessing the viability of the proposed project that may reduce the likelihood the project is taken forward.

Limitations

- As the electricity mix in the New York and Los Angeles area changes, the emissions from EVs will change and must be updated in the model accordingly.
- The cost of installing a fueling station for an EV fleet at the carrier's distribution centers can significantly increase the total lifecycle cost. EVs come with lower cost of maintenance and increased fuel economy than their conventional vehicle counterparts.
- Both models assume a package price based on the cost/pounds/year a brand transfers; the actual pricing structure in the contracts between brands and carriers is more complex and relies on other key zoning factors aside from weight and mileage.
- Determining the actual improvement in air pollution is beyond the scope of this model. Further research should be conducted and a separate analysis, to calculate the long-term reduction in air pollutants is needed.
- Due to a variety of incentives, Model B: Lease-based is currently only available in Los Angeles.

Findings

The added value of brand equity that comes with transforming industry practices is not reflected in the model's cost savings; there is also no long-term analysis or economic output that captures the effect on an entity's share price or ESG rating.[49] The model solidifies the benefits for the brand(s) and carriers through the co-financing of EVs including emissions reductions and potential to reduce financing costs for both parties, outlined in Chapter 2. The dual-model approach provides insight into two potential ways brands and carriers could enter into a co-financing agreement. In the next section, the importance of incentives and financing mechanisms for the purchase or lease of EVs will be highlighted as there are significantly differing capital costs for fleet electrification in the two cities of interest: New York and Los Angeles.

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Chapter 2: Los Angeles and New York City Cost Comparison

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Chapter 2: Los Angeles and New York City Cost Comparison

Comparative Cost Analysis

A comparative cost analysis was done between Los Angeles (LA) and New York City (NY) that reviews EV penetration, infrastructure, and the allotted federal, state, local, and utility incentives that support the use of EVs. This can be seen in Figure 13.

Los Angeles, California: The California Air Resources Board's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)[50] Total Cost of Ownership (TCO) calculator was used to determine the upfront capital and operational costs for an EV step van compared to Diesel step van in both LA and NY. The HVIP voucher of $90,000 for a step van with a gross vehicle weight rating (GVWR) of 14,001 - 19,500 to be used in disadvantaged communities[51] in Los Angeles was applied to the upfront capital cost of the vehicle. Revenue generated from selling credits on the Low Carbon Fuel Standards (LCFS) market in California was included in the TCO. The HVIP default credit price of $134.10/MT[52] was used as the average credit price for the estimated 12-year life of the EV step van. Our estimated installation of EV Infrastructure was $16,354 for a level 2 charger[53] based on the California Air Resources Board Advanced Clean Truck TCO document. Assuming one level 2 charger for two electric Class 4-5 trucks, we included incentives available from Los Angeles Department of Water and Power (LADWP) Charge UP LA incentive for Electric Vehicle Charging Stations of $5,000[54] in order to offset the upfront purchase and installation cost of the level 2 charger. However, the level of incentive is highly dependent on the number of parking spaces available at the site and number of electric delivery trucks needed, so the amount of incentive is subject to change based on the site of the EV and EV chargers. Carriers will be able to utilize these incentives to lower both the cost of installing the EV chargers and the TCO of the Electric delivery trucks.

New York, New York: Similar to California, New York recently approved the New York Truck Voucher Incentive Program (NYTVIP)[55] which provides funding for all-electric and alternative fuel trucks and buses. We used the Voucher Amount and Cap of $110,000 allowed for the purchase or lease of a Class 4-5 vehicle with GVWR of 14,001 - 19,500 lbs.[56] to offset the upfront capital cost of the electric truck in NY. To stay consistent with our TCO calculation for LA, we included a $5,000 EV charging infrastructure incentive[57] for level 2 chargers as part of the Charge Ready NY program.

	Los Angeles, California	New York, New York
Electric Vehicle Delivery Truck		
Total Cost of Ownership EV Delivery Truck	$172,488	$182,078
Cost/lbs./year	$1.12	$1.18
Diesel Delivery Truck		
Total Cost of Ownership Diesel Delivery Truck	$184,674	$170,700
Cost/lbs./year	$1.23	$1.14
Savings to Brand ($/lbs.)	**$0.11**	**($0.04)**

Figure 13: Cost Analysis for an EV truck in Los Angeles and New York City

Chapter 2: Los Angeles and New York City Cost Comparison

Incentives & Infrastructure

Below is a comprehensive list of available incentives for EVs and EV infrastructure in Los Angeles and New York City.

Jurisdiction	Title of Each Incentive[58]	Type	Amount
Federal	Qualified Plug-In Electric Vehicle (PEV) Tax Credit	Federal Incentive	$2,500- $7,500
	Alternative Fuel Infrastructure Tax Credit	Federal Incentive - Infrastructure	30% of the cost; < $30,000
California	Alternative Fuel Vehicle (AFV) and Fueling Infrastructure Grants	State Incentive	Undisclosed
	Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)	State Incentives	Undisclosed
	Low Emission Truck and Bus Purchase Vouchers	State Incentives	$2,000 - $315,000
	Plug-In Hybrid and Zero Emission Light-Duty Vehicle Rebates (Clean Vehicle Rebate Project)	State Incentives	$1,000 - $4,500
	Electric Vehicle Supply Equipment (EVSE) Rebate - Southern California	State Incentives	$40,000, or 75% cost
	Electric Vehicle Supply Equipment (EVSE) Rebate for Businesses - SCE	Utility	Undisclosed
	Electric Vehicle Supply Equipment (EVSE) Rebate - LADWP	Utility	$5,000, $750 per extra charge port
	Zero Emission Medium- and Heavy-Duty Vehicle Program	Utility	Undisclosed
	Clean Vehicle Rebate Project	State Incentive	$1000-$4500
	Low Carbon Fuel Standard Program (LCFS)	State Incentive	>$134/MT Credit
	Los Angeles Total Incentives + Federal Incentives: 13		
New York	Alternative Fuel Vehicle Research and Development Funding	State Incentives	Undisclosed
	New York Truck Voucher Incentive Program (NYTVIP)	State Incentives	$30,000 - $150,000
	Alternative Fueling Infrastructure Tax Credit	State Incentives	$5,000, or 50% of cost
	Plug-In Electric Vehicle (PEV) Rebate Program ("Drive Clean")	State Incentives	$2,000
	Workplace Electric Vehicle Supply Equipment (EVSE) and Plug-In Electric Vehicle (PEV) Incentives	State Incentives	$8,000 per EVSE
	New York City Total Incentives + Federal Incentives: 7		

Figure 14: State, Federal, and Utility Sponsored Incentives for EV and EV Infrastructure Equipment: New York vs. Los Angeles

Chapter 2: Los Angeles and New York City Cost Comparison

Considerations: EV Charging Between NY and LA

For the purpose of this report and model, we have assumed the EVs will make deliveries during the day and charge overnight. We used the emissions factor for the average generation mix in both California and New York in our GHG emissions reduction calculations and average retail electricity rate in each city for the TCO calculations. Further considerations need to be made to the operation of the EVs in each city in order to optimize charging based on the generation mix and electricity rates in each city.

California: There should be a consideration for the EVs to charge in the middle of the day to use the excess solar generation so they can take advantage of lower electricity rates produced by the duck curve. Deliveries would be best suited for later in the afternoon and evening to avoid using generation from natural gas peaker plants, high time-of-use rates, and peak demand charges. Optimizing charging in California could increase the total emissions reduction and lower the TCO of the EV fleet.

New York: Charging overnight during off-peak hours in New York will be most cost-effective. Off-peak uses baseload generation most often from natural gas combined cycle power plants and could decrease the total emissions reductions. As more renewable energy generation from wind and battery storage projects are brought on-line in New York, this could help improve the emissions from baseload generation.

Findings

Given the available incentives in California compared to New York, the Total Cost of Ownership of an EV is lower in Los Angeles than in New York City. While the NYTVIP has made the cost of ownership much more economical compared to a diesel truck in NY and EV in LA, the upfront capital cost is still too high for Model A: PPA to be cost-effective for brands.

In Model A: PPA for Los Angeles, the LCFS program in California is one of the main drivers for the cost-effectiveness of EV trucks in LA. It provides a revenue stream for the life of the vehicle that can be used to offset the ongoing fuel, maintenance, and insurance expenses of the truck. For the TCO of EV trucks in New York to decrease, more incentives like the market based LCFS need to be enacted to offset the large capital expense and ongoing costs of an EV truck. Additional model guidelines can be found in Appendix 9.

Figure 15 shows the potential benefits of adoption of EVs in New York City and Los Angeles. The annual fuel cost per kWh for EVs in New York and Los Angeles are currently cheaper than per gallon of diesel. As outlined in Chapter 1, EV deployment in last mile delivery is expected to reduce emissions by 74 percent in LA and 69 percent in New York. The difference in reduction is due to a slightly cleaner grid in the LA area.

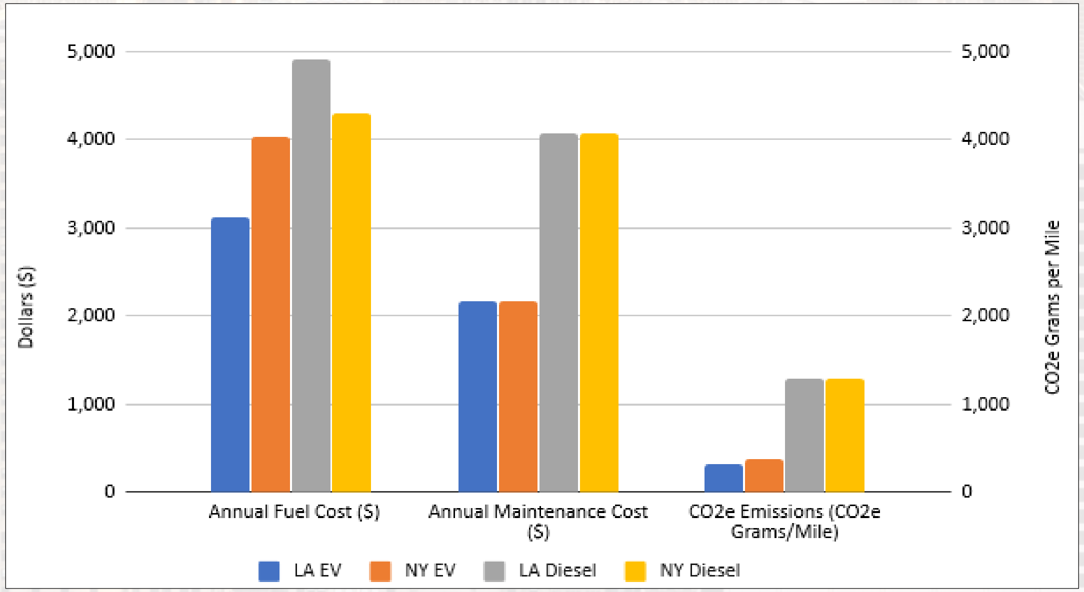
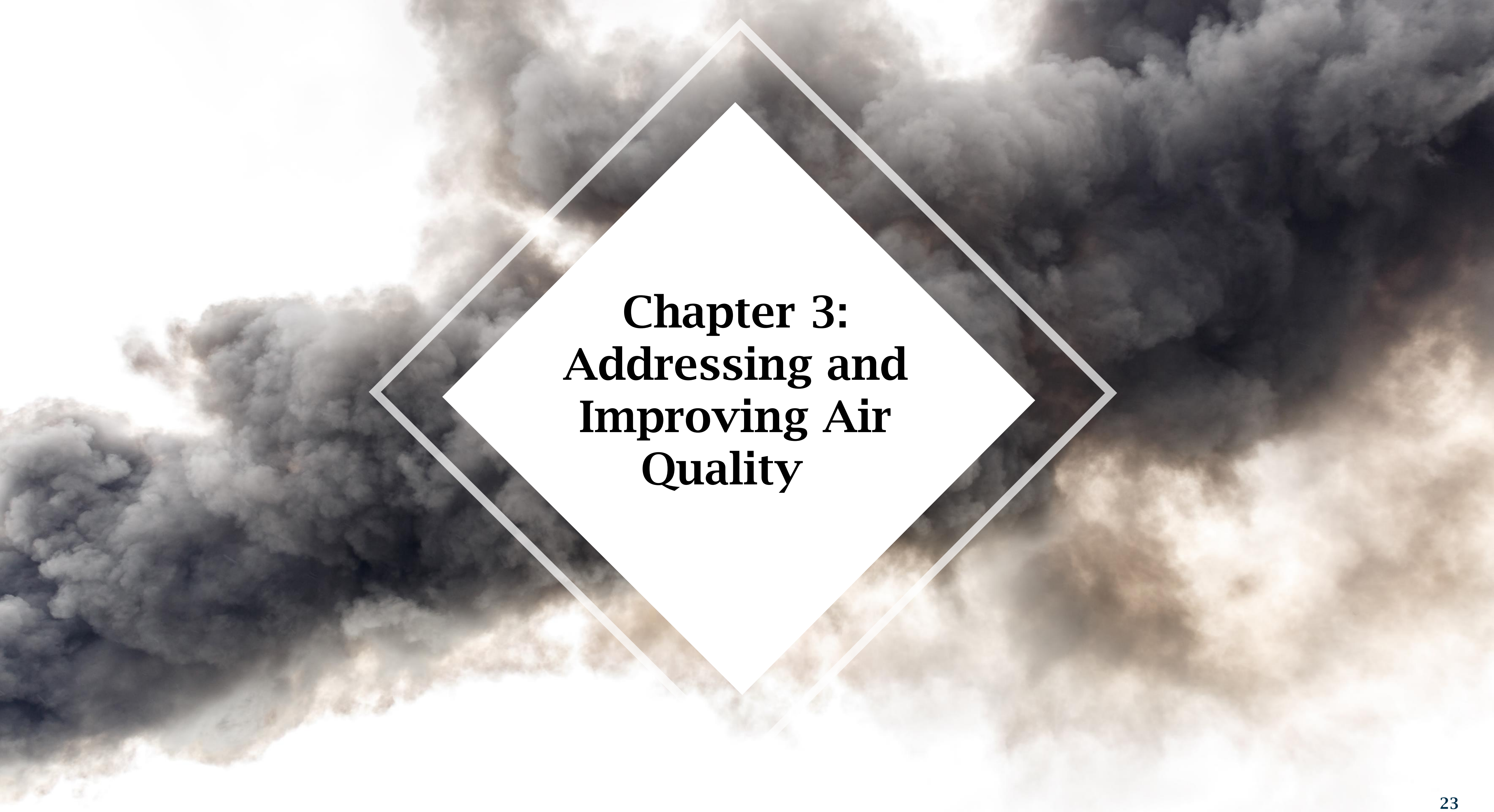


Figure 15: Potential Benefits of EV Adoption in LA and NY



Chapter 3: Addressing and Improving Air Quality

Chapter 3: Addressing and Improving Air Quality

Health Impacts of Air Pollution

Since the implementation of the Clean Air Act in 1970 and other clean air policies, the air quality and health of Americans have improved.[59]. The demand for online shopping is increasing delivery vehicles on the road, and subsequently, the amount of air pollutants in the environment. Apart from GHG emissions, Particulate Matter 2.5 ($PM_{2.5}$), Nitrous Oxide ($NO_{x,}$), Carbon Monoxide (CO), Volatile Organic Compounds (VOC), and Ozone (O_3) are additional air pollutants that can be found due to increased vehicular transportation.

O_3 is formed as a chemical reaction to sunlight when NO_X and VOC are present, resulting in severe respiratory problems when inhaled. $PM_{2.5}$ comes from all kinds of combustion activities that mainly include the burning of fuel in vehicles and power plants. It is one of the smallest and most harmful urban air pollutants that penetrates deep into the lungs and bloodstream. It may cause severe respiratory and cardiovascular health complications.[60] Short and long term effects of air pollution on human health include worsening asthma, wheezing, shortness of breath, stroke, lung cancer, and cardiovascular disease.[61]

In New York City, 17 percent of all $PM_{2.5}$ emissions come from traffic. Similarly, in Los Angeles, vehicular traffic is the biggest source of $PM_{2.5}$. It contributes to premature deaths and an increased number of emergency department visits each year. [62]

The Global Burden of Disease Study 2015 (GBD 2015 risk factors collaborators 2016) estimated the health effects of outdoor ambient PM2.5 and ozone, and reports that PM2.5 accounted for 92 percent and ozone for 8 percent of premature deaths (GBD 2015 risk factors collaborators 2016.[63]

New York City and Los Angeles have annual excess mortality rates that can be linked with high levels of $PM_{2.5}$ and O_3 levels.[64] On average in New York City, $PM_{2.5}$ emissions result in 320 premature death and 870 emergency department visits and hospitalizations each year.[65] In 2017, Los Angeles had the highest death rate caused by $PM_{2.5}$ and O_3 in the country. The cities of Los Angeles and Riverside account for 89 percent of deaths linked to air pollution in California, and almost a third of excess deaths (deaths caused by specific exposure) in the U.S.[66]

Impact of Air Pollution on Low-Income Neighborhoods in Los Angeles

In Los Angeles, the comparatively low-income areas of Downtown and Chinatown are those most affected by air pollution and have high levels of $PM_{2.5.}$These areas are densely populated and have busy freeways in the heart of the city. As a result, these areas have the most hours in a day in which $PM_{2.5}$ levels rise above 100 on the AQI scale.[67]

Wilmington, a poor neighborhood in Los Angeles suffers from high car and truck traffic from the two freeways that sandwich the area. The resulting air pollutants are a mix of emissions from cargo ships, delivery trucks, and refineries. The area has one of the state's highest rates of asthma. Residents complain of headaches, nosebleeds and other symptoms that are exacerbated by air pollution.[68]

Vehicles traveling roadways in neighborhoods with low-income and high-density of susceptible populations are at risk.[69] A 2015 study in Los Angeles, modeled the spatial effects of $PM_{2.5}$ on low term birth weight which is spread across the county, represented in Figure 16.[70]

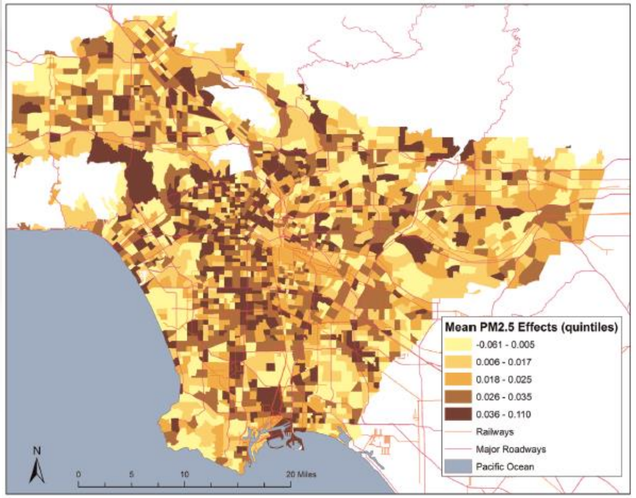


Figure 16: $PM_{2.5}$ in Los Angeles[71]

Chapter 3: Addressing and Improving Air Quality

Battling Air Pollution in New York City's Low-Income Neighborhoods

In New York City, the impact of $PM_{2.5}$ levels from all the traffic sources is 50 percent times greater in the high-income neighborhoods compared to low-income neighborhoods.[72] New York City's $PM_{2.5}$ levels are 1.09 µg/m^3 and 1.64 µg/m^3 in low and high-income areas respectively, and show that the areas having high $PM_{2.5}$ levels are high poverty areas, outlined in the figures below.[73] On-road traffic mobile sources in the region contribute to high rates of $PM_{2.5}$ that results in asthma-related emergency department visits that are 8.3 times higher in the very high poverty neighborhoods as compared to the low poverty neighborhoods.[74]

In 2013, a group of residents in Bronx County, New York sued Fresh Direct for severely impacting the air quality of the local area.[75] A strong association can be found between Bronx County zip codes and high asthma rates.[76] Residents inhale the emissions of hundreds of daily delivery trucks coming in and out of the Fresh Direct warehouse. The constant traffic on the four nearby highways adds to exhaust emissions. Residents of the area require asthma hospitalization at five times the U.S national average, and at rates 21 times higher than other New York City neighborhoods.[77] MIT Senseable City Lab used cellphones to track air quality conditions,[78] including levels of $PM_{2.5}$ in New York City, to identify hotspots, which is shown in Figure 17a and b.

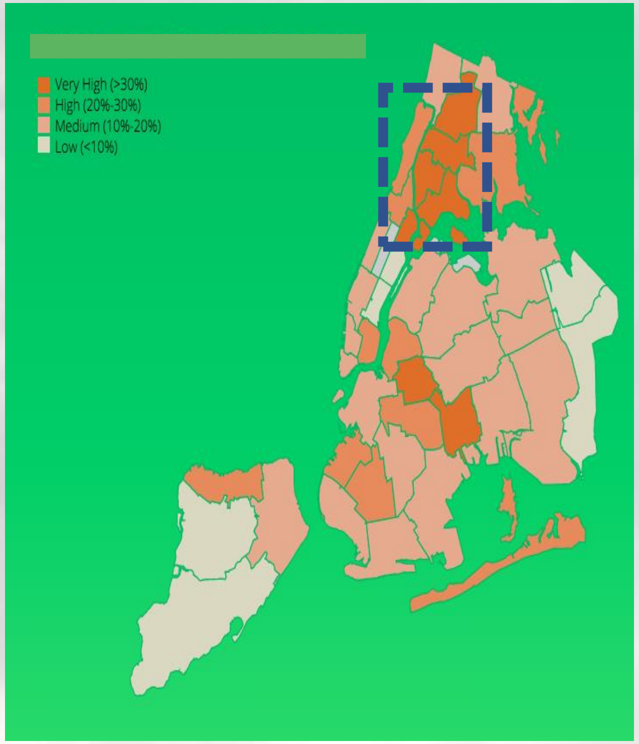


Figure 17a: Poverty Levels in New York City[79]

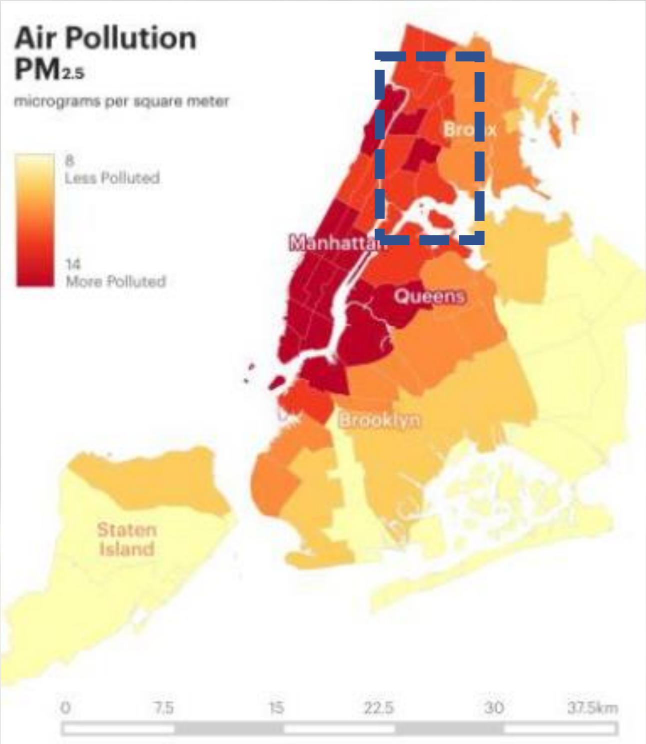


Figure 17b: Air Pollution $PM_{2.5}$ in New York City[80]

Chapter 3: Addressing and Improving Air Quality

Critical Mass to Improve Air Quality

The EPA outlines an acceptable level of annual $PM_{2.5}$ at an average of 12 micrograms per cubic meter of air (µg/m^3).[81] Several districts in New York City are close to that limit, including areas in the Bronx, or exceed it in the case of Midtown Manhattan.[82] The World Health Organization (WHO) has set guidelines[83] for $PM_{2.5}$ that call for an annual mean of 10 µg/m^3.

Improving air quality is a necessary and feasible benefit of EV adoption for last mile delivery. To quantify impact and scale up, a critical mass point must be established. Using the EPA's BenMap Tool we calculated reduction of air quality pollutants and dollar-per-ton value. The following assumed criteria were used in the calculation:

- Diesel Class 4-5 Truck with a Gross Vehicle Weight Rating between 14,001 – 19,500 lbs.
- Time period: Annual
- Air Quality Pollutants: CO, NO_x, VOC, and $PM_{2.5}$

Leveraging the data in the EPA's BenMap Tool we calculated the individual reduction of an EV, annually and found 0.078 MT of air quality pollutants (CO, NO_x, VOC, and $PM_{2.5}$) and a dollar-per-ton value of $68,103. The dollar-per-ton value takes into account health benefits and overall economic benefit due to avoided excess death(s) and healthcare costs.

Due to the health impacts that increasing air pollution is generating in the low-income areas, it is imperative that measures are taken to reduce emissions from vehicles within the city limits.

Through research and industry stakeholder interviews, we assumed a reduction goal of 1 MT of $PM_{2.5}$ and NO_x, annually. 1 MT is the critical mass point, which can be met through the replacement of 13 diesel trucks with at least 13 EV trucks as outlined in Figure 18. Reaching this critical mass point has the potential to improve air quality; particularly, those in low-income neighborhoods, such as Bronx County, where there is an abundance of daily delivery trucks. Scaling the number of EVs making last mile deliveries throughout these areas can serve as a significant proponent to reducing average pollutant levels of community districts. Coordinating with the logistics network for these deliveries to ensure EVs are deployed in neighborhoods that currently do not meet EPA or WHO standards should be exercised, with a minimum of 13 EVs taking the place of diesel delivery trucks for a reduction of at least 1 MT of air pollutants modeled.

# of EV Trucks in Fleet	Air Quality Pollutant Reductions (MT of CO,NO_x, VOC, $PM_{2.5}$) / year	$/Ton value of avoided emissions (CO, NO_x, VOC, $PM_{2.5}$) / year	TCO of EV Fleet (LA)	TCO of EV Fleet (NYC)
1	0.07846	$68,103	$167,488	$177,078
5	0.39230	$340,516	$809,049	$856,999
10	0.78460	$681,032	$1,618,098	$1,713,998
13	**1.01998**	**$885,342**	**$2,103,527**	**$2,228,197**
15	1.17690	$1,021,548	$2,427,147	$2,570,997
20	1.56920	$1,362,064	$3,236,196	$3,427,996
25	1.96150	$1,702,580	$4,045,245	$4,284,995

Figure 18: Critical Mass of EVs for Air Quality Reduction
(Model Available Here)

Chapter 3: Addressing and Improving Air Quality

Emissions Reduction

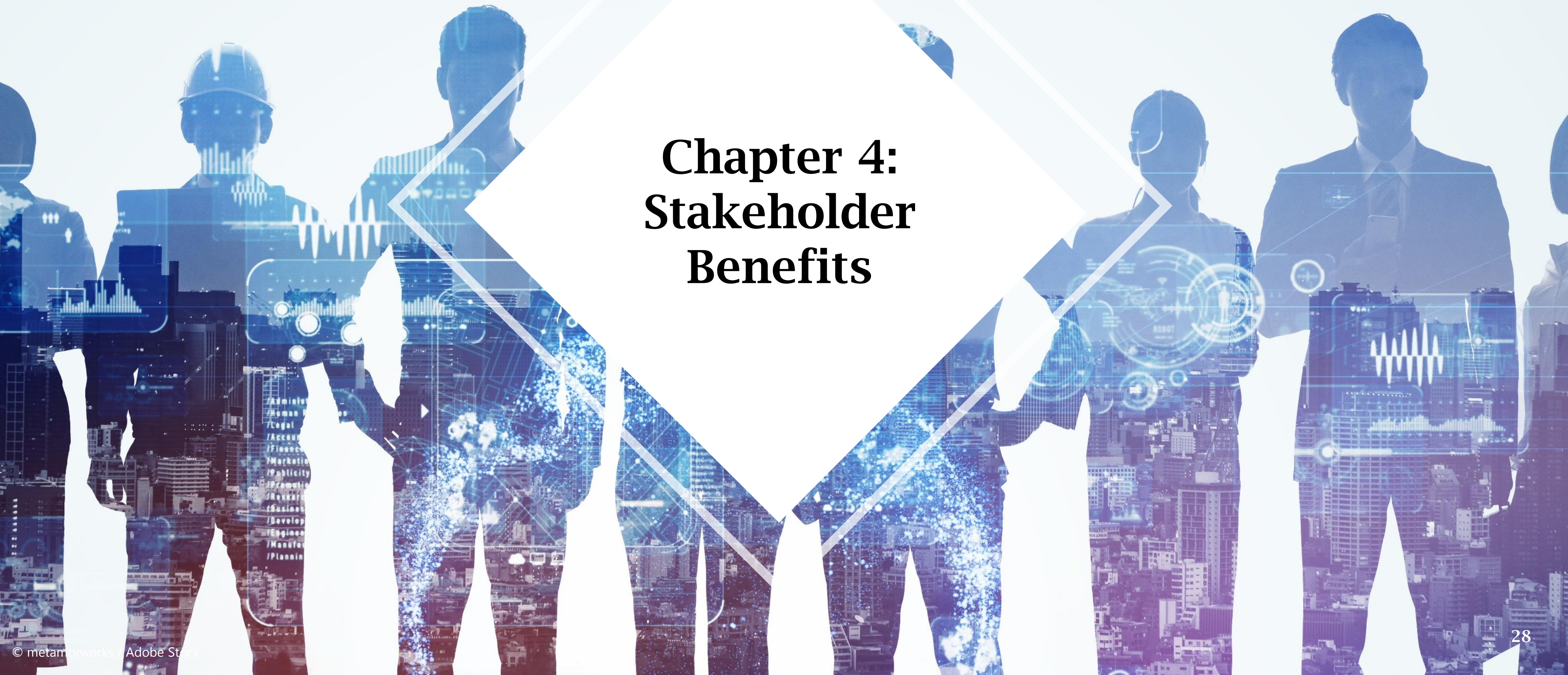
Leveraging the same assumptions outlined in Chapter 1, the switch from diesel trucks to EVs in both Los Angeles and New York proves favorable for local air pollutant reductions and the total amount of metric tons of CO_2e emissions offset, as outlined in Figure 19 (Sources in Appendix 9).

Carriers and the brand(s) will need to scale up EVs to make have an impact and meet local air pollutant reduction goals and air quality standards. As the number of EV trucks in the fleet grows, so will the reduction in pollutants and total dollar benefits provided to the community. As a result, the purchasing power of multiple brands can increase the need for more EVs and have a meaningful impact on air quality in polluted neighborhoods.

Diesel Truck	Los Angeles	New York
Miles per Gallon of Delivery Truck	10.00	10.00
Total Gallons Consumed Per Year (Diesel)	1,311.60	1,311.60
Upstream Emissions per Gallon of Diesel Generation (kg of CO_2e/gal)	2.47	2.47
Tailpipe Emissions per Gallon of Diesel (kg of CO_2e/gal)	10.39	10.39
Total Emissions Per Year (kg of CO_2e)	16,867.18	16,867.18
Total Local Emissions Per Year (Metric Tons CO_2e)	**16.87**	**16.87**
Total Emissions Per Year (kg of CO, NO_x, VOC, and $PM_{2.5}$)	78.46	78.46
Total Emissions Per Year (Metric Tons CO, NO_x, VOC, $PM_{2.5}$)	**0.078**	**0.078**
Electric Vehicle Truck	**Los Angeles**	**New York**
Average kWh/Mile	1.4	1.4
Total kWh Per Year	18,362.40	18,362.40
Total MWH Per Year	19.24	19.26
Total Output Emissions Subregion (lbs. of CO_2e/MWH)	CAMX: 498.7	NYCW: 597.8
Tailpipe Emissions (lbs. of CO_2e/MWH)	-	-
Total Output Emissions Per Year (lbs. of CO_2e)	9,596.88	11,512.72
Total Output Emissions Per Year (kg of CO_2e)	4,353.07	5,222.08
Total Output Emissions Per Year (Metric Tons of CO_2e)	**4.35**	**5.22**
Total Emissions Per Year (kg of NO_x, SO_2)	4.45	2.48
Total Emissions Per Year (MT of NO_x, SO_2)	**0.0045**	**0.0025**
Emissions Reduction	**-74.19%**	**-69.04%**
Emissions Offset (Metric Tons of CO_2e) Annually	**12.51**	**11.65**

Figure 19: Emissions Reduction from EVs

Chapter 4: Stakeholder Benefits



Chapter 4: Stakeholder Benefits

Benefits and advantages of a brand coalition

The fundamental feature of the Virtual Delivery Emissions Model is how it allows the brand(s) to calculate different emissions reduction outcomes based on whether they pursue a PPA or lease-based agreement individually, or as part of a multi-brand coalition. The brand(s) can quantify the benefits of each scenario and assess how the economic and environmental savings will differ if they act collectively versus acting alone. This is a critical function of the model because it helps steer a brand's decision towards how to better achieve their goal of improving air quality.

Effectively scaling EV solutions through collective action will provide a cumulative impact on air quality by reducing diesel emissions. The speed and scale necessary to reduce air pollutants within the last mile, will have further reaching benefits if all brands take action together; not just by electrifying its own fleet.[84]

The inherent value in collective action is exemplified through the success of similar initiatives, such as EV100, a global initiative by The Climate Group, and The Corporate Electric Vehicle Alliance (CEVA), launched by the Ceres Organization. EV100 is a group of companies worldwide committed to making "electric transport the new normal by 2030" by shifting to EVs.[85] The latter initiative, which was newly established in January 2020, has the similar aim of "accelerating the electric vehicle revolution via fleet vehicles", but specifically across the U.S. Participating companies include Amazon, AT&T, DHL, Ikea North America, and Siemens.[86]

Both coalitions provide a platform for committed companies to engage with policymakers, industry players, investors, and other stakeholders who shape EV markets. Collective action comes with a set of unique advantages that enable change to happen at a speed and scale no individual brand can achieve alone .

1. **Increased Influence and bargaining power to drive policy.** The group's combined influence enables them to lobby for policies that support their efforts, including improved state and federal policies that accelerate the development of EV infrastructure.

2. **Mobilizes EV demand.** By publicly committing to purchasing carbon-free fleets, brands leverage their aggregated demand to expand the EV market and accelerate demand for EV fleet services. This enables manufacturers to achieve greater economies of scale and, therefore; manufacture them more rapidly, affordably and with a wider range of models.

3. **Encourages brand leadership and fosters camaraderie.** A platform allows brands to showcase their leadership while inspiring other brands to join in and take action. This will further momentum behind the movement to achieve their goals. Collaboration also enables brands to learn from one another in regards to industry best practices.[87]

4. **Setting a new standard.** Developing a data-driven "narrative" around EV economic and environmental savings will build consensus around fleet electrification as a new normal. This new narrative illustrates the clear monetary benefits from reduced fuel and maintenance costs, freedom volatile oil and gas prices, improved company reputation, and enhanced employee recruitment and retention.[88]

5. **Reduce costs and improve air quality.** Given the cost effectiveness of the lease model, a coalition of brands brings more available capital and the potential to lease more EVs. If multiple brands are willing to lease one EV each, this could help simplify the data accounting and easily attribute the GHG, $PM_{2.5}$, CO, VOC, and NO_x emission reductions that can be claimed by each brand. The more brands that are included in the PPA Model, the less each brand will be responsible for contributing to the pounds of packages shipped by that EV.

"If Brands want to pay and tell consumers that their packages get delivered from EVs, even when that vehicle also carries other Brand's packages, it could be a leadership moment. It is as simple as that." - Bill Loftis, Senior Director of Integrated Solutions, Transportation Insight

Chapter 4: Stakeholder Benefits

Brands

1. **Ability to measure and reduce last mile delivery emissions (Scope 3).** Brands are setting ambitious energy reduction goals which can be achieved by eliminating CO_2e across their entire value chain. The most difficult emissions to address come from the last mile delivery of their products. These emissions are reflected in Scope 3 accounting, which occurs outside the company's own operations. Under the model's framework, and using the Corporate GHG Protocol[89] for compliance, a brand captures Scope 1 and Scope 2 emissions generated by the carrier. See Appendix 10 for more details.

2. **Financing a Carbon Offset Project.** This model provides a program where the brand can compensate their emissions by funding a CO_2e reduction program through deployment of EVs for the last mile delivery. Through the measures outlined in Appendix 10, the brand may seek to register the program as a carbon reduction ("offset") program which requires verification against the international standards.

Hypothetically, as a financier of a carbon offset program, a brand leveraging the Virtual Delivery Emissions Model could claim a carbon credit per ton of CO_2 avoided in their package being delivered by an EV rather than a diesel truck. Under the California carbon-credit market, where renewable energy certificates (RECs) are traded, the Virtual Delivery Emissions Model will have to be developed in accordance with the California Air Resources Board (CARB) and approved Compliance Offset Protocols.

The state of New York has strict standards for what constitutes an offset project, which does not contain eligibility for this transport emissions-related project. In order to register the proposed offset project in New York State, one must see if transportation initiatives qualify and obtain the relevant compliance application for submission.

The structure of the financing model between carriers and brands must be developed to ensure a brand counts emissions reduced/offset against their Scope 1 and 2 accounting. While a carrier allows for the brand to claim the carbon credit generated to avoid duplicity of credits and to abide by regulations of carbon credit markets.

3. **Meeting Consumer Demands.** Consumers are looking for brands that place increasing importance on sustainability issues. A 2018 global survey conducted by Accenture noted that 30,000 consumers found that 62% of customers want companies to take a stand on current and broadly relevant issues like sustainability, transparency or fair employment practices.[90] Younger consumers are expecting businesses to integrate moral decision-making into every aspect of the business.[91] In some markets, consumers are not only voting with their dollars, they are demanding companies to lower their carbon footprint. According to *From Me to We, The Rise of the Purpose-led Brand*, two-thirds of customers believe their actions—from posting comments on social media to participating in boycotts—can influence a brand's reaction to an event or its stance on an issue of public concern.[92] Brands will need to demonstrate how they are looking beyond profit-margins to do the right thing.

4. **Sustainability Strategy:** EV fleets could help address brands' sustainability goals; which could include air quality improvements, GHG emissions reductions, community benefits and partnerships. Investing in EV fleets could strengthen the symbiotic relationship between the brand(s) and carrier; publishing commitments on both ends and increasing transparency to consumers and communities.

"Carriers are the downstream part of a Brand's supply chain. Brands have the ability to control, to some degree, through contracting and partnerships with carriers what type of fleet is used."

– Jonathan Dickinson, Professor, Columbia University (Appendix 14)

Chapter 4: Stakeholder Benefits

Brands continued.

6. **Competitiveness.** Given the shift in consumer expectations indicated above, more brands will highlight their best sustainable practices to create a competitive edge. By tuning into customers' beliefs and taking decisive action, brands can connect with consumers and build relationships on a deeper level. The closer a company's purpose aligns to their customers' beliefs, the more likely they can acquire and retain consumer loyalty.[93] Figure 20, reviews current brand profiles for the largest retail companies in the U.S., which showcases their investment into EVs.

	Amazon.com, Inc.	Walmart Inc.	Target Corporation
Business Model	Multinational technology company	Multinational Retail Corporation	US Retailer
Products:	E-commerce, cloud computing, digital streaming, and artificial intelligence	Hypermarkets, discount department stores, and grocery stores	Hypermarkets, discount department stores, and grocery stores
Sustainability Goals:	• 100% Net zero carbon by 2040 • 80% Renewable energy by 2024 • 100% Renewable energy by 2030 • 50% Shipments net zero carbon by 2030[94]	• Achieve an 18% emissions reduction in our own operations by 2025, compared to a 2015 baseline. • By 2030, work with suppliers to reduce or avoid carbon dioxide equivalent (CO_2e) emissions from Scope 3 by 1 gigaton from global value chains. • Be powered by 50% renewable sources by 2025.[96]	• Reduce absolute Scope 1, 2 and 3* greenhouse gas emissions by 30% below 2017 levels by 2030. **From retail purchased goods and services* • 80% of our suppliers will set science-based reduction targets on their Scope 1 and 2 emissions by 2023.[97]
Sustainability Report	2019	2019	2019
Electric Vehicle Activity	100,000 fully-electric delivery vehicles, the largest order ever for electric delivery vehicles	EV chargers available at 110 retail locations across 29 states	• Expand the current EV program to more than 600 parking spaces at over 100 sites across more than 20 states with charging stations over the next two years.[98] • Target will continue their work with ChargePoint and Tesla to install charging stations in the parking lots at more than 100 stores and other Target properties.[99]
Last Mile Activity	About 62% of Amazon's packages are delivered by USPS, with another 21% by UPS and 8% via FedEx.[95]	None	1,800+ stores across the country and three-fourths of Americans are within ten miles of a Target store.[100]

Figure 20: Sustainability Profiles of Retailer Giants

Chapter 4: Stakeholder Benefits

Carriers

1. **Reduced Emissions.** By leasing or outright purchasing EVs for their delivery fleets, carriers can reduce their Scope 1 emissions. Carriers can pass on these benefits to brands through a reduction of Scope 3 emissions. As the grid across the United States becomes increasingly fueled by renewables, the reduction in greenhouse gas emissions from EVs will become even more significant.[101]

2. **Reduced Costs.** By switching out internal combustion engine vehicle fleets with EVs, carriers are lowering their fuel and maintenance costs.[102] These savings are relative to the price of available vehicles and cost of electricity in the city they are operating in. EV owners in the U.S. have been found to pay one-quarter to one-third of what owners of conventional vehicles pay in fuel costs on average.[103] As seen in Model A: PPA, the average fuel cost in Los Angeles is $0.17 per kWh, meaning EV users in LA will save more on fuel than in New York, where electricity is $0.21 per kWh. In cities where incentives for EVs are sparse, the upfront investment for EVs will be higher than conventional diesel trucks.

3. **Competitiveness.** Brands are making commitments to reduce their carbon footprint. Based on the assumption that a majority of brands have not efficiently taken action to reduce last mile delivery emissions, there is an opportunity for carriers to provide low-carbon logistics (e.g. UPS Carbon Neutral Program). If a carrier is able to guarantee a brand that their deliveries are placed in EVs, this service would distinguish them from other market players. This point is exemplified through Gnewt Distribution's acquisition of all ASOS deliveries. Following ASOS's carbon reduction pledge, Gnewt was the only carrier to quickly offer one of the UK's largest retailers the opportunity to provide zero-carbon emission last mile delivery.[104]

4. **Brand Equity.** By investing in EV fleets, carriers can evolve and adapt to modern technology trends. Research suggests that businesses who are agile and constantly innovate will booster their brand value because they become regarded as industry leaders.[105]

5. **Zero Emissions.** While EVs have positive benefits in reducing GHG emissions, local air pollution, and public health, EV deployment will not combat congestion in cities. The use of EVs will not lessen the number of delivery vans on the road but replace the existing mode of transportation. EVs produce zero-emissions, therefore, carriers could eliminate fees incurred from idling, which is defined as when a vehicle is stationary but still burning fuel.[106]

Cities

1. **Reduced Scope 1.** Deployment of EVs would result in a reduction of Scope 1 emissions for the city. According to the *Greenhouse Gas Global Protocol for Community-Scale Greenhouse Gas Emission Inventories*, "Cities shall report all GHG emissions from combustion of fuels in transportation occurring within the city boundary in Scope 1, and GHG emissions from grid-supplied electricity used for transportation within the city boundary for transportation in Scope 2."[107]

2. **Environmental Benefits.** As of September 2019, over half of the 50 largest cities in the United States (based on population) had adopted local climate action plans.[108] Many of these plans include reducing overall greenhouse gas emissions and have specific reduction goals for transportation-related emissions.

Chapter 4: Stakeholder Benefits

Cities continued.

3. **Improved Air Quality and Public Health Outcomes.** A 2019 study from Northwestern University documented the differences in air pollution from internal combustion engines and EVs. This research shows that EVs have a net positive impact on air quality, despite consuming fossil fuels from electricity use.[109] The adoption of EVs is correlated with a reduction in ozone and particulate matter, both of which are public health indicators. The public air quality improvements and associated health outcomes from EVs are difficult to quantify and vary across locations. However, one estimate revealed the health effects associated with diesel vehicle emissions are 20 times that of EVs.[110] Through the use of EVs in last mile deliveries within urban areas, local air quality will improve; as there are no exhaust emissions at the street level when using EVs, but there remains some particulate matter from road, tire, and brake wear.[111]

4. **Financing Mechanisms.** Leveraging green bonds can help finance a carbon-zero last-mile delivery future. A green bond is a conventional bond specifically designed to fund projects that generate environmental benefits. In recent years, they have become a popular and important instrument for mobilizing private capital towards climate change solutions, particularly in non-green sectors where the natural environment is financially material.[112] In June 2017, Apple issued a $1B green bond to finance renewable energy and energy efficiency across its buildings and supply chain. In February 2019, Verizon Communications launched a similar $1billion bond to fund their own renewable energy investments.[113]

   As companies utilize fixed-income products to fund sustainable initiatives, demand for climate-friendly investment opportunities is also rising.[114] In 2019 alone, global annual Green Bond issuance increased by 49% from 171.1 billion to 254.9 billion in 2019.[115] Although they still represent a sliver of the $100 trillion global bond market, green bonds are expected to keep growing as a tool to finance adaptation and resilience projects.[116]

A bond can be designed in partnership with carriers, brands, and cities, or, individual stakeholders can also be incentivized to launch their own bond given the ancillary benefits it can provide. Green bonds offer companies the opportunity to broadcast their commitment to the environment, and have been argued to improve long-term value, share price, operating performance, and environmental performance.

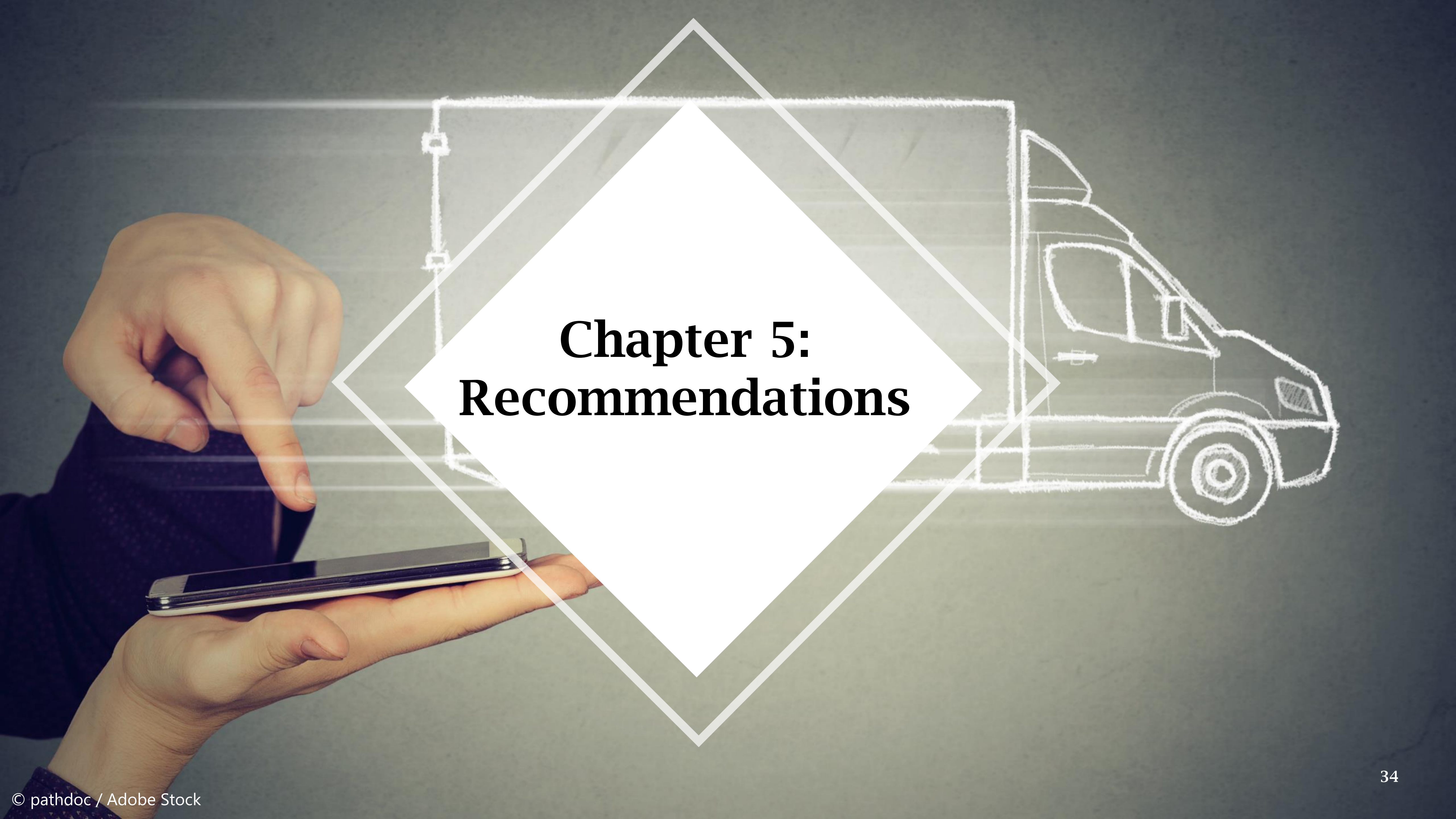
Moreover, this green bond must be able to achieve third-party verifiable emissions reductions that show net- positive environmental impacts. There will also need to be established methodologies for reporting emissions reductions, along with outcome-oriented performance metrics that meet specified standards set by the Global Reporting Initiative (GRI) or the US-based Sustainable Assurance Standards Board (SASB).[117]

Consumers

1. **Improved Consumer Experience.** Consumers will be able to shop online while minimizing their contribution to emissions in connection to last mile deliveries. Consumers enjoy making purchases when they understand the product's entire value chain.[118]

2. **Increased Transparency.** Over recent years, increasing light has been shed on how conventional business supply chains contribute to ecological damage. This gave rise to the distrusting consumer, who now expects full transparency across a product's entire value chain, especially further upstream. By understanding the last mile delivery processes, consumers can begin building their trust.[119]

3. **Rewards and Incentives.** Brands have the opportunity to reward and incentivize consumers who choose to select an EV delivery option for their purchase. This incentive could be a discount towards their next purchase or loyalty rewards. Consumers are the drivers of the business and a key consideration for EV deployment. The examples in Appendix 11 demonstrate how brands are allowing consumers to offset the emissions from their purchase.



Chapter 5: Recommendations

Chapter 5: Recommendations

Brands

1. **Collaborate with Carriers and Other Brands.** To effectively reduce the investment in capital required to deploy EVs, the brand(s) with an e-commerce channel must collaborate with their carrier and amongst one another. The more collaboration, the more cost effective the use of EVs becomes for both the carrier(s) and the brand(s), making deployment more feasible.

2. **Allocate Capital to Low Carbon Initiatives.** The brand(s) can expand their investment in reducing emissions throughout their operations, supply chain, including fulfillment centers. This type of investment is a signal to public actors of the readiness of the private sector to engage with low carbon transport solutions.

3. **Prioritize Corporate Social Responsibility (CSR).** While the smaller brand(s) may not have enough capital to invest in large scale mitigation strategies, they can partner with non-profits and non-governmental organizations (NGOs). These included the United Nations Sustainable Development Goals and the Climate Group's EV100, who are working to increase EV presence and improve air quality in major cities. Through this, the brand(s) could also publicly support the United Nations Sustainability Development Goal 13, which focuses on climate change.[120]

4. **Publish a GHG Inventory.** To effectively use the Virtual Delivery Emissions Model, the brand(s) must track and report their GHG emissions, including emissions from last mile delivery to enhance transparency throughout the supply chain.

Carriers

1. **Invest in Technology Improvements.** Increased transparency on the individual weight of packages, vehicle miles traveled in the last mile, and vehicle type should be provided to e-commerce clients. This will enable brands to make more informed decisions on where to invest their corporate sustainability budgets with regards to emissions reductions goals. This will equally inform the carriers' internal goal setting and strategy.

2. **Market the Benefits.** Carriers should conduct an analysis of the potential long-term cost savings for switching out their existing internal combustion vehicles with an electric fleet. By providing the brand(s) a clear comparison of all the costs associated with owning and maintaining an electric fleet versus fuel-based, they can market themselves as a way for the brand(s) to reduce their Scope 3 emissions while reducing logistics costs.

3. **Invest in EV Infrastructure.** In order to propel wide-scale EV deployment, the carrier(s) must take on a leadership role in making charging infrastructure widely available. The carrier(s) must work with utilities to upgrade the electrical service at their facilities in order to provide the necessary power for charging fleets of EVs. Generally, infrastructure remains a pervasive hurdle to EV adoption.[121]

4. **Publish a GHG Inventory.** The carrier(s) should map, and make publicly available, an annual GHG inventory so that their reductions are properly measured and taken into account.

"Carriers with fleets have an advantage compared to cities who are planning for the public to adopt EVs. Fleets can be planned more efficiently to reduce the level or charging needed and can operate with cheaper and easier (slower) charging as opposed to a city that has to plan for passenger vehicles needed to charge quickly to and from their destination."

- Crysta Jentile, Greenlots

Chapter 5: Recommendations

Cities and States

1. **Policy Incentives.** Air quality legislation on a global scale is expected to increasingly restrict polluting vehicles in cities. Los Angeles is a C40 Signatory and has committed to creating zero emission zones by 2030[122] and New York has committed to net-zero emissions city wide by 2050 through OneNYC.[123] This is a driver for the city government and administration to implement more local laws and incentives like grants, tax rebates, and subsidies in favor of EVs, so that the brands and carriers are encouraged to work together. These incentives should also include the financing and establishment of publicly available EV infrastructure. Doing so will put less economic pressure on the carriers to finance and build charging infrastructure, and lessen the barrier of adopting EV fleets. Penalizing vehicles that emit dangerous greenhouse gas emissions should also be considered. Mechanisms for doing so can include, but are not limited to, congestion pricing, taxing diesel vehicles, increasing-state fuel efficiency standards, or passing idling laws for commercial fleets. Currently for New York State, the Charge NY initiative is offering EV buyers (both new cars and leases), the Drive Clean Rebate of up to US $2,000 and a Federal Tax Credit of up to US $75,000. There are also over 2,000 public charging stations in New York State.[124] Los Angeles has a Used EV rebate program and a rebate for the purchase of EV chargers for residential and commercial customers, in addition to a federal tax incentive, a state government rebate, access to HOV (High Occupancy Vehicle) lanes and more.[125]

2. **Air Quality Tracking.** As discussed in Chapter 3, current air quality is typically measured using the EPA's Air Quality Index (AQI). The AQI monitors five major air pollutants[126] regulated under the Clean Air Act: ground level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Although AQI is highly accurate it is sufficiently location - specific. Air pollutants such as No_x and $PM_{2.5}$ vary dramatically over short span of time and short distances so they need to be measured continuously at multiple locations. The cost of installing and maintaining real time sensors is relatively high.[127] Hence, cities should invest in real time, local tracking systems that have sensors spread throughout the city to measure and mitigate air quality in a more precise way.

3. **Renewables in the Energy Mix.** Cities must ensure efforts to electrify local transportation are coupled with a greater share of renewables in its energy mix. The use of EVs will increase a carrier's electricity consumption and the emissions calculated for that energy production will be based on the regional electricity grid. By working with the state government, cities can advocate for legislative mechanisms that will deliver a cleaner electricity grid. Doing so will improve the emissions factor used in calculating a brand or carrier's emissions when using the proposed model, ultimately driving emissions reductions from private transportation.

4. **Widening the Carbon Offset Program Registry.** In order for this model to be accepted as an offset program by a state or an international carbon market, cities and states must collaborate on expanding the requirements for the offset program mentioned in Appendix 10 . Accredited offset verifiers can be directed by a state's regulatory body or certification agent (e.g., The Gold Standard) to widen the parameters of approval for an offset program. Doing so would add volume to the supply and demand of carbon markets and catalyze greater commercial investment for emissions reductions by complying companies. This should be coupled with state or federal emission caps for the e-commerce industry to bind them to a specific compliance period, which forces them to support the financing of programs like the one proposed in this report to meet new emissions restrictions.

5. **Improve Data Accounting.** Develop a database of EV brand-to-carrier financing projects that includes costs, incentives, and life-cycle GHG emission benefits. Doing so provides the basis for scenario modeling of the mitigation potential and contribution to the city and state's GHG emissions reduction goals. The database should include information on existing fleets of EVs such as who owns and operates them, what the primary use of the EVs are, and where they're primarily parked and charged. By publicly releasing the database and synthesis report, cities provide guidance for further public and private investment as part of capital allocation for meeting mitigation targets.

Conclusion

Based on our assumption presented in the Virtual Delivery Emissions Model, the estimated reduction is between 11 – 12 MT of $CO2_e$ emissions through the replacement of a diesel truck with an EV, depending on the city. We recommend the adoption of 13 EVs for last mile deliveries in order to reduce 163 MT of $CO2_e$ emissions in LA and 152 MT of $CO2_e$ emissions in NYC, and improve air quality by 1 MT annually.

As cities continue to seek ways to mitigate growing greenhouse gas emissions and air pollution, reforming the supply chain of a fast-growing e-commerce retail space presents an opportunity. The rapid increase of EVs, with improving cost and performance, has the potential to improve air quality when integrated as a strategy for last mile deliveries.

The maturity framework (in Appendix 8) is a benchmarking tool for the brand(s) to assess cities and carriers for EV readiness, based on the given criteria. Following a review of efforts by online retailers, carriers, and cities in adopting EVs, it is clear that last mile fleet electrification is still an emerging field. Improving last mile delivery has been sought after as a differentiating factor in this fast-growing market space.[128]

A group of brands should work with a carrier to implement a rate structure into their pricing terms where delivery via an EV will be charged for a specified dollar amount per pound of packages. Private financing of electric delivery vehicles by an individual brand, or a coalition of brands, is unlikely without adequate support. The market for large-scale commercial EVs will continue to grow as long-term cost trends head downward and more companies seek to improve business value and reduce their environmental impact. Important advancements to enable brands to use EVs for their last mile delivery would be to reduce reliance on third-party delivery fleets and provide adequate financing.

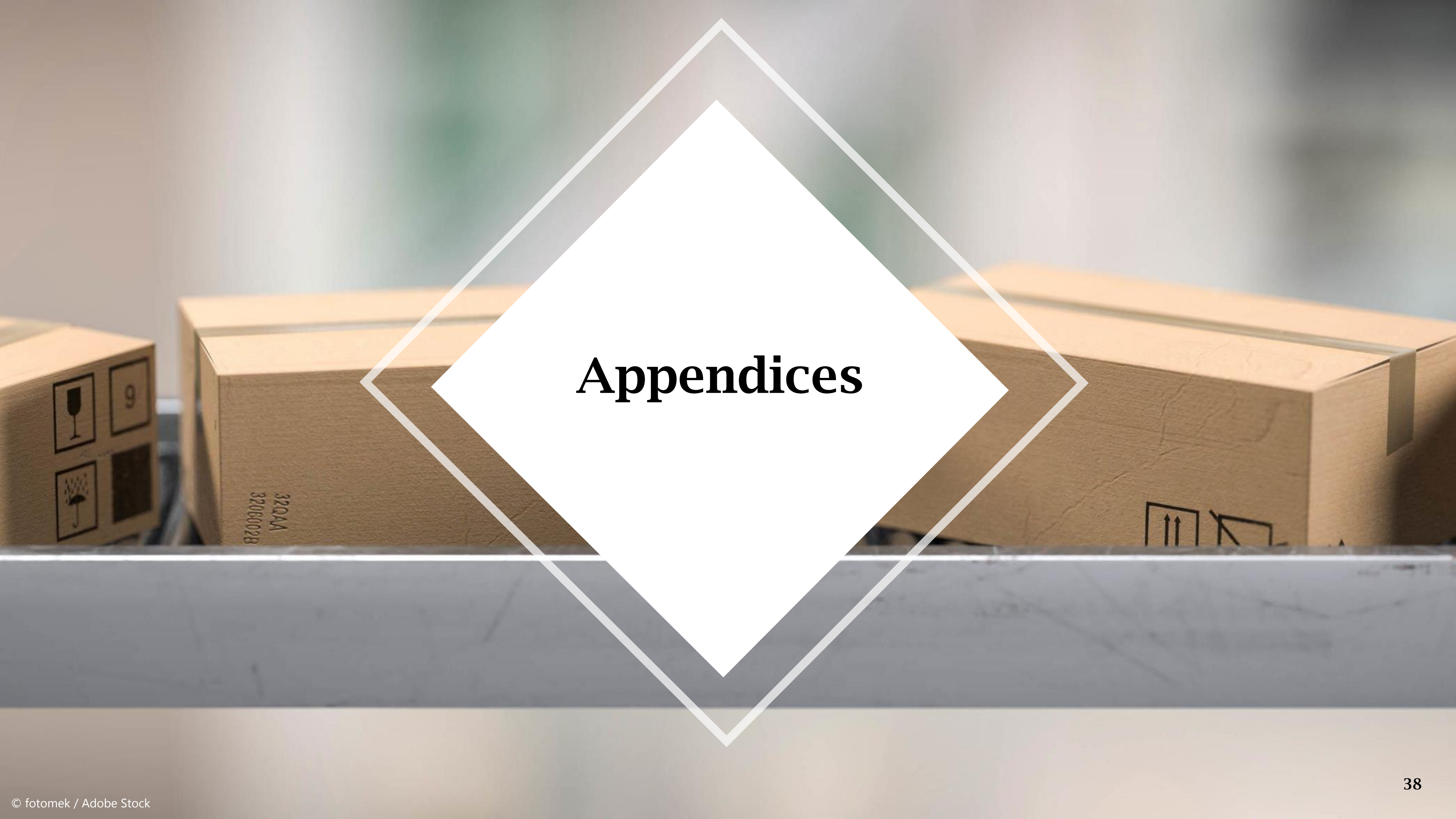
Both models proposed in this report require the brand to evaluate available monetary and nonmonetary incentives available in the location where the EVs will be purchased and operated. This includes tax credits, rebates, and financial assistance, as well as investment intensity and maturity of charging infrastructure. As discussed in chapter two's findings, the upfront capital cost for brands using model A will vary depending on the city it operates in that may render it too high for the model to be cost-effective. These variables help gauge the expense of funding the EV project and inform which model is best for a brand.

The proposed Virtual Delivery Emissions Models should be tested with real clients (i.e. brand(s) and carrier(s)) in a real scenario to collect and report on the data findings. Implementation will come with a few challenges that can be resolved with better research in the EV area. At present, there is no clear way to account for emissions that have been reduced via co-financing of an EV being used for the last mile deliveries. It is important to explore how brands can claim a carbon offset from the emission reductions. Another crucial factor will be to determine how contracts would work between carriers and brands to enable the purchase of EVs with funds provided by the latter.

Further research should be conducted to identify facilities that could host and charge EVs, current source of energy, charging patterns, electricity service at facilities, charging infrastructure,[129] and additional financial incentives for Los Angeles and New York City.

In sum, every stakeholder of the last mile ecosystem must review and reform their supply chain practices to transition to lower-carbon modes of transport. Brands can play a leading role in this shift by using one of the proposed models and applying it to their last mile ecosystem, in partnership with carriers and cities, to support rapid EV adoption for last mile deliveries.

Appendices



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Appendix 1: Last Mile Solutions

Last mile delivery is defined as the last stage in the logistics process, where goods move from a transportation hub to the final destination, typically the home of an individual consumer. Many international cities have implemented mitigation programs aimed to lessen the environmental impacts caused by last-mile delivery. These include:

- **Parcel Locker Systems.** Parcel lockers are becoming increasingly popular as a cost-efficient and flexible option to mitigate delivery traffic. In Poland, InPost Parcel Lockers are unattended delivery machines located at convenient and accessible public places. This system enables consumers to both receive and ship parcels 24 hours a day, 7 days a week. At present, there are more than 3000 machines implemented in 20 different countries.[130]

- **Route Optimization and Real Time Information Systems.** Truck routing and the decision support system synthesizes real-time traffic data to help drivers optimize delivery routes. In Vienna, the Intelligent Freight Logistics in Urban Areas (ILOS) is a Freight Routing Optimization project that uses traffic data to optimize delivery routes.[131]

Cities worldwide are implementing policy incentives and subsidies to accelerate EV deployment. Below include two critical, widely embraced policy mechanisms that helped expand the EV market.

- **Congestion Pricing.** London, Stockholm and Singapore have implemented congestion pricing to reduce the traffic congestion and encourage people to use public transportation. In 2007, Stockholm enacted a congestion tax by using cameras that automatically capture vehicles via license plate recognition technology. The goal of the scheme was to improve air quality and public health.[132]

- **Low Emission Zones (LEZs).** Many European cities have implemented low emission zones that restrict the entry of diesel-emitting vehicles. In Amsterdam, LEZs have been in effect since 2013. From 2022 on, only electric or hydrogen-powered buses and coaches will be allowed into the city center. Amsterdam's goal is to be emissions-free from all forms of transportation by the end of the decade.[133]

Appendix 2: Brand Overview

Our research focused on how global e-commerce brands are addressing urban last mile delivery emissions, tracking Scope 3 emissions, the overall current landscape of corporate sustainability pledges. We specifically analyzed multi-national corporations with active e-commerce channels and global reach, including Amazon, Walmart and Target. Case studies, journals and articles helped develop five key criteria that indicate which brands are best positioned to aid the acceleration of EV deployment:

1. **Corporate Sustainability Reports.** Creating annual sustainability reports that reaffirm and document environmental goals each year. Understanding how much the brand is currently investing and accounting for the reduction in GHG emissions across the value chain.
2. **Established Science Based Targets.** These are targets set by businesses and corporations in order to reduce their total GHG emissions in line with mandated decarbonization levels to keep global temperature increase below 2°C.[134]
3. **Emissions Tracking.** In the form of a GHG Inventories or reports through the Carbon Disclosure Project. Understanding how much brands are committing to measuring and and reducing GHG emissions across their value chain.
4. **Renewable Energy Certificates (RECs) and Carbon Offsets.** Proactively purchasing RECs or funding carbon offset programs to reduce global GHG emissions. While brands might not be in a position to fully integrate carbon sequestering projects into their supply chain, purchasing offsets to mitigate their impact is considered a best practice.
5. **Last Mile Footprint Mapping.** The average distance of last mile delivery to consumer, based on location of fulfillment centers or rented real-estate including parcel lockers and micro-distribution centers. Based on a Coldwell Banker Richard Ellis (CBRE) report, the average distance for last mile deliveries can range from six to nine miles.[135] Urban areas are closer to last mile facilities compared to suburban communities. Mileage between the center and the end consumer does not account for: location of the center, age of center, technology being used, or EV charging ports.
6. **Capital Allocation for EVs.** The brand(s) should consider financial appropriations made for investment in EV infrastructure/fleets, as well as for advocating and subsidizing their respective carrier(s).

Appendix 3: Carrier Overview

Last mile delivery accounts for a significant chunk of revenue for carriers worldwide. As shown in Figure 21**,** last mile deliveries make-up over half of all delivery costs.

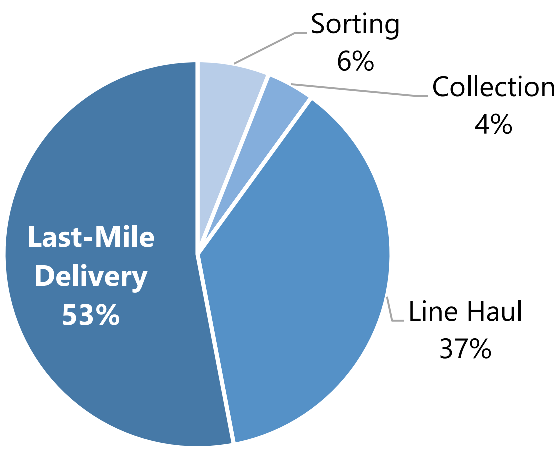

Figure 21: Share of Delivery Costs [136]

In the United States, key carriers in last mile delivery for e-commerce orders include FedEx, USPS, UPS and DHL.[137] To fulfill growing demand, each carrier has invested in differentiating their delivery options so customers can pay for better service and faster shipping. As carriers increasingly invest in minimizing their carbon footprint, more attention has been placed on last mile delivery solutions. To understand the various these strategies, we audited carriers' corporate sustainability reports and last mile mapping/mitigation strategies. Research gleaned from these reports led to the development of three key criteria that indicate which U.S. carriers would make ideal partners for brands in the adoption of EV deployment.

1. Corporate Sustainability Goals & Emissions Tracking. Corporate sustainability reports across all industries are becoming increasingly mainstream. Most reports include emissions tracking systems (typically in the form of verified GHG inventories), and boast initiatives addressing reductions in emissions, waste, water pollution, among other environmental indicators. Today, over 300 brands spanning several industries have set Science Based Targets. These targets signify how companies are making formal and verified commitments to combat climate change. The three largest domestic carriers in the United States have unique corporate sustainability reports and reported reduction goals, which are explored below.

2. Last-Mile Mapping & Mitigation. Currently, carriers are not explicitly tracking last mile deliveries. The corporate sustainability reports published by carriers do not contain explicit data on emissions outputs caused by this last stage in the logistics process. To mitigate these emissions, carriers typically use unique route optimization technologies in conjunction with some level of urban planning insight to improve route efficiency. To reduce mileage, some carriers have invested in micro-distribution centers. These also provide opportunity for delivery via foot or bicycle. Lastly, some carriers have invested in liquid natural gas or EVs to mitigate emissions as well.

3. Capital Allocation for EVs. Improving environmental impacts and lowering the total cost of ownership are underlying factors for fleet electrification.[138] According to the EPA, the transportation sector accounts for the largest portion of total U.S. GHG emissions.[139] The use of electric commercial fleets helps carriers reduce their emissions and reach their sustainability goals. Simultaneously, EV options are becoming more cost competitive due to a gamut of federal, state and local financing incentives to expand the EV market. However, despite a growing interest and the falling costs costs, barriers to EV adoption include upfront capital and a lack of charging infrastructure.

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Appendix 4: Carrier Profile

These profiles provide a snapshot of findings from each carrier across corporate sustainability goals, last mile mitigation techniques, and investment in EVs. These findings informed the maturity framework and allowed the research team to categorize each carrier's approach to the metrics as a high, medium or low effort.

	DHL[140]	FedEx[141]	UPS[142]	USPS[144]
Sustainability Goals	• Zero-emissions logistics by 2050	• Increase vehicle fuel efficiency by 50% (from a 2005 baseline) by 2025	• Reduce Scope 1 emissions by 25% by 2025 (includes postal-owned fleets) • Reduce Scope 3 emissions by 30% by 2025 (includes contracted transportation) • Have 25% of total fleet rely on alternative fuel or EVs by 2025	• Source 40% of all ground fuel consumed from either low carbon or alternative fuels by 2025
Last Mile Delivery Mitigation Strategies	• Dynamic route optimization technology • Expanding delivery by foot, bicycle and electric or natural gas-powered vehicles for short distances • Piloting micro-distribution centers for concentrated pickups and returns	• Dynamic route optimization technology • Piloting a program in Oklahoma with tractor-trailers that run entirely on liquid natural gas • Investments in EVs in California and NY	• On-Road Integrated Optimization and Navigation (ORION) / UPSNav • Investment in alternative fuels and EVs • UPS Carbon Neutral Shipping	• Dynamic route optimization technology • Investments in EVs in California and New York
Investment in EVs	• Deployed 9,100 electric Street Scooters in partner cities across the globe for short distance deliveries	• Added 1,000 electric delivery vans from Chanje into its fleet; deployed in California • Entered into a joint project with Columbia University and GE where they deployed 10 EV's in Manhattan	• Smart Electric Urban Logistics (SEUL) pilot: deploying a fleet of EVs in the city of London in partnership with PS, U.K. Power Networks and Cross River Partnership, with funding secured from the U.K.'s Office for Low Emission Vehicles • Purchased 10,000 EVs from Arrival[143]	• Operates a fleet of 30 EVs in New York City • Piloting a program of seven Motiv-power Ford E-450 vans in California's Central Valley

Figure 22: Carrier Sustainability Profiles

* Published in an annual Corporate Sustainability Report. Related to emissions from fuel/deliveries

Appendix 5: Current Carrier Landscape

Using the three carrier criteria: 1) Corporate Sustainability Goals 2) Last-Mile Mapping 3) Capital Allocation to EVs, the research team defined metrics for what constitutes a high, medium and low effort. A breakdown of those metrics and information on how each carrier scored can be seen in Figure 23.

Metric	High	Medium	Low
Corporate Sustainability Goals & Emissions Tracking	Carrier has a corporate sustainability report with a GHG inventory with an SBT & directly purchases emissions offsets (DHL, FedEx)	Carrier has a corporate sustainability report with a GHG inventory with an SBT & provides customers with an opportunity to purchases emissions offsets (UPS)	Carrier has a corporate sustainability report with a GHG inventory with an SBT but does not purchase or offer any emissions offsets to customers (USPS)
Last Mile Mapping & Mitigation	Carrier uses dynamic route optimization and has invested in both micro distribution centers and alternative fuels (DHL)	Carrier uses dynamic route optimization and has invested in either micro-distribution centers or alternative fuels (FedEx, UPS, USPS)	Carrier uses dynamic route optimization and has not invested in either micro- distribution centers or alternative fuels
Capital Allocation to EVs	Carriers have 10,000 EVs or more	Carrier has between 1,000 and 10,000 EVs (UPS, FedEx)	Carrier has less than 1,000 EVs (USPS)

Figure 23: Carrier Maturity Framework

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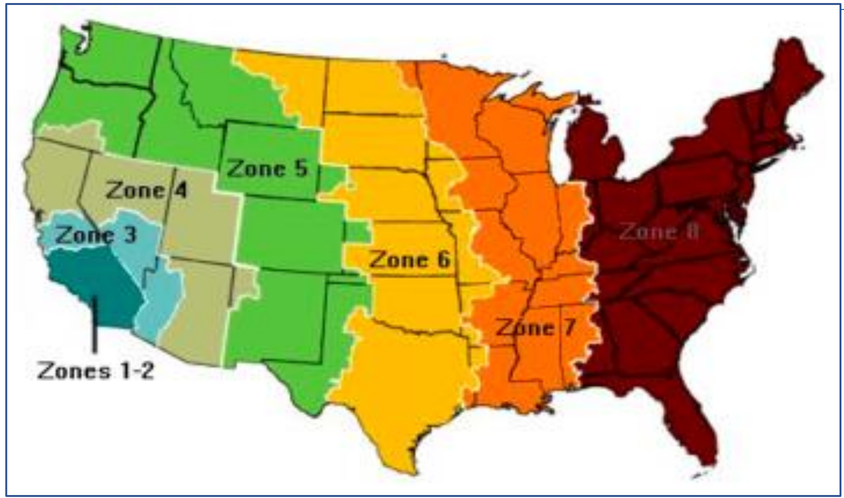
Appendix 6: Carrier Zoning and Distribution Facilities

Division into Zones: Carriers measure the distance between the point of origin of a package and its destination in terms of zones. Zone 1 would be the origin point and the farthest point the destination could be is zone 8. Considering the U.S. has 2,500 miles of delivery (coast to coast), they have used that measure to split up zones. Zone 1 is a 50 mile radius and Zone 8 is 1801+ mile radius. This can give us an idea of how far a package has travelled: the farther a package has travelled from its origin point, the more zones it has crossed. Shipping carriers base fee structures based on these zones and hence, knowing the zone also helps in calculating shipping costs.[145]



[146]

Figure 24: What the mile –radius of each zone looks like in relation to the size of the United States

The success of e-commerce depends heavily on maximizing efficiency of delivery zones. One of the challenges here is that a majority of the U.S. population (~50%) lives on the coasts. Figure 25 shows USPS' price increase as the zone increases. It is important for brands to find ways to reduce their zoning to cut costs and also reduce the emissions from their shipments.[147]

L, 1 & 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
0%	20%	28%	38%	16%	11%	17%

Figure 26: USPS' price increase per zone

Distribution Centers

FedEx: 13 Fulfillment Centers in the United States:

Atlanta, GA; Blaine, WA; Buffalo, NY; Champlain, NY; Chicago, IL; Dallas, TX, Detroit, MI, El Paso, TX; Laredo, TX; Los Angeles, CA; Port Huron, MI; San Diego, CA; Seattle, WA[148]

UPS: Number of Fulfillment Centers and Locations specific to the United States could not be found.

DHL: 3 Fulfillment Centers in the United States; Exact locations unknown but can be approximated from Figure 27.

Figure 27: DHL U.S. Fulfillment Centers Map[149]

Appendix 7: Adoption of Electric Vehicles in Global Cities

The U.S. EV market is miniscule compared to international economies. For this reason, the team conducted extensive research into policy decisions and market forces that enabled a few international cities to become the "electric-vehicle capitals of the world." [150] We established the following research questions: 1) What mechanisms allowed these cities to have high rates of EV penetration and how were they financed? 2) What policies propelled the market, promoted EV-adoption, and help financed charging infrastructure? 3) How are cities monitoring their air quality? Which systems and methods are most prevalent? An example of the research conducted is displayed in Figure 28, which illuminates various EV incentives for international cities.

	London, England[151]	Shanghai, China	Copenhagen, Denmark
Low Emissions Zones (LEZ)	Yes	No	Yes[154]
Congestion Tax	Yes	No	No
Financial Incentives	• Federal grant up to 4,500 pounds at EV purchase • EVs exempt from annual circulation tax • Federal grant of an additional 3,000 pounds for zero emission capable taxi	• Federal subsidies of up to 54,000 CNY and tax exemptions • Exemption from restrictive license plate auctions (80,000 CNY savings)	• Exempt from vehicle registration taxes (up to 180%) until 2016; partially exempt until 2020 • Exempt from annual car tax • Tax refunds on electricity used to charge EVs
Non-financial incentives	• Exemption from congestion charges • Free or reduced parking costs in select boroughs	• Subsidies for reserved parking in Jiading District • Regional subsidies of up to 30,000 CNY	Designated free parking
Financing Mechanisms	• Government funded charging infrastructure for public use • Non-Government funded charging points: Five networks are responsible for installing, operating and maintaining public charge points across London, offering pay as you go charging and membership schemes for frequent users	• Private investment in infrastructure equipment; joint ventures between car manufacturers and charging operators have formed to target development and competing for market share[152]	• The City is participating in European Union projects aiming to promote EVs and develop a common European charging infrastructure • Car manufactures and service providers are collaborating create public infrastructure
Air Quality Monitoring System	• Network monitoring stations, which shows real time air quality measurements and GIS data across London • Over 100 state-of-the-art sensor pods on lamp posts and buildings throughout the city, continuously transmitting air quality measurements	• 24-hour, real-time air-quality monitoring stations across Shanghai • The official app of the Shanghai Environmental Monitoring Center shows the air quality index and the exact real-time readings from each station around the city[153]	• Nationwide network of air pollution measuring stations, strategically placed in heavily trafficked streets, urban areas, and open areas far from major sources of pollution • In partnership with Google, the city launched an air quality map with Google Street View instruments which shows block-by-block concentrations of black carbon and ultrafine particle pollution

Figure 28: Financial and Political Strategies to Transform the EV Market

Appendix 8: Maturity Framework Overview

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CARRIERS					
CRITERIA	**DEFINED METRICS**	**DEFINITION**	**HIGH**	**MEDIUM**	**LOW**
EV STRATEGY	Electric Vehicles	Carrier has evaluated or scoped a potential investment or use of electric vehicles for delivery.	Has Invested	In Progress	Not Scoped
LAST MILE MAPPING	* Distance to Fulfillment Center * Real-estate (Parking Lots, Garage)	Using any of the below for last mile delivery efficiency methods: - Route Optimization Technology - Investment in Alternative Fuels - City Planning	>=2	1	0
EMISSIONS TRACKING SYSTEMS & SUSTAINABILITY GOALS	* Corporate Sustainability Report * Offsets and/or SBT	Based on online/publicly available reporting. Most carriers have corporate sustainability reports with reduction goals. The reports all look similar and contain similar information on reduction strategies. The main difference in the report that is significant for this model is the presence of offsets (either purchasing them directly, offering them to customers or not reporting on offsets at all).	Carrier has a corporate sustainability report with a GHG inventory with an SBT and directly purchases emissions offsets.	Carrier has a corporate sustainability report with a GHG inventory with an SBT and provides customers with an opportunity to purchases emissions offsets.	Carrier has a corporate sustainability report with a GHG inventory with an SBT but does not purchase or offer emissions offsets to customers
CAPEX	* Capital Allocation (for EVs)	How much capital is the carrier currently allocating towards EVs? CapEx specific to EV is not available for the carriers. Hence the distinction here will be made based on number of EVs already added to fleet and number of EVs committed to purchase already.	>=10,000 EVs	1,000 to 10,000 EVs	<1,000 EVs
	* Brands	Current carriers in the space.	DHL	UPS, FedEx	USPS (~ less than 50)

BRANDS					
CRITERIA	**DEFINED METRICS**	**DEFINITION**	**HIGH**	**MEDIUM**	**LOW**
BRAND EQUITY	* Corporate Sustainability Report * Offsets and/or SBT	Methods For Reporting Brand Equity: 1) SBT Target 2) CSR/ESG Report	SBT Target **AND** CSR/ESG report	SBT Target **or** CSR/ESG report	No SBT Target **or** CSR/ESG report
EMISSIONS TRACKING SYSTEMS	* GHG Inventory	How much is the brand currently investing in and accounting for and reducing the emissions across their value chain: - Reports on Scope 1,2,3 - Mentions Last Mile Delivery in Scope 3	Brand accounts for and publicly reports on scope 1, 2, and 3 emissions. Brand states last mile deliveries are included in scope 3 calculations.	Brand accounts for and publicly reports scope 1 and 2 emissions. Brand mentions last mile delivery in recent CSR report but may not be addressing scope 3 at this time.	Brand accounts for and publicly reports on scope 1 emissions and does not mention last mile delivery in recent CSR report.
LAST MILE MAPPING	* Location of Fulfillment Centers * Real Estate (Parcel Lockers, Micro-DC's, crowdsourcing)	Based on a CBRE report, the average distance for last mile deliveries can range from 6-9 miles. Generally speaking, urban areas are closer to last-mile facilities, while more suburban areas are farther from last-mile facilities. Mileage between the center and the end consumer does not account for: location of the center - is it near a major highway, how old is the center and what kind of technology is being used, are there EV charging ports at the center? In addition to investing in closer, newer, more high-tech fulfillment centers, brands also need to invest in shipping alternatives like parcel lockers, micro-DCs, and crowdsourced shipping.	Brand measures last mile delivery mileage and sets reduction goals. Brand invests in fulfillment center improvements including but not limited to new technology and EV charging ports on site. Brand invests in variety of alternative shipping methods including but not limited to parcel lockers and crowdsourced shipping.	Brand measures last mile delivery but does not specifically address reductions. Brand provides minimal investment in fulfillment centers, maybe minor improvements. Brand provides minimal investment in alternative shipping methods, likely only one alternative option to date.	Brand does not measure last mile delivery mileage and does not mention intention to do so. Brand does not invest in fulfillment center upgrades or publicly discuss improvements. Brand does not invest in alternative shipping methods and mention intention to do so in the coming year.

The Maturity Framework can be accessed here

Figure 29a: Key Criteria Identified in the Maturity Framework

Appendix 8: Maturity Framework Overview

GOVERNMENT & CITY INFRASTRUCTURE (U.S. Only)					
CRITERIA	**DEFINED METRICS**	**DEFINITION**	**HIGH**	**MEDIUM**	**LOW**
EV PENETRATION	* % of EV Sales in a City	Total EV sales/ Total car sales *100.	>20% Total sales (e.g. Oslo)	10-20% Total sales (e.g. San Jose)	< 10% Total sales (e.g. New York city)
INCENTIVES FOR INFRASTRUCTURE DEVELOPMENT	* Subsidies * Tax Breaks * Financing Mechanisms (Grants, Loans, PPAs, Regulated Pricing)	Policy makers using an incentive-based approach to encourage private investment in infrastructure development. Ranking is determined by the presence and aggressiveness of incentive structures. This grading system and policy determinants were replicated from "Electric Vehicle Capitals of the World: Demonstrating the Path to Electric Drive" (2017) published by The International Council on Clean Transportation. "MEDIUM" rank is flexible and includes the majority of cities that show a mix of federal incentives, with 1-2 tax incentives or subsidies available.	Multiple incentives on federal and state level; grants and tax incentives	1-2 Incentives or subsidies	No incentives
ENERGY SUPPLY MIX	* Renewable Energy Supply Mix Based on Percentiles	Distribution of renewable energy supply mix for each city as recorded in the 2018 CDP data, specifically cities in the 25th, 50th, and 75th percentile. Cities with greater than 75% renewable energy were in the 75th percentile, 7% - 70% placed in the 25th and 75th percentile, and less than 7% placed in the 25th percentile. Numbers were rounded down.	>75%	70% - 7%	<7%
POPULATION DENSITY	* Public Transportation * Congestion * Route Optimization/City Planning	The below strategies can encourage public transportation, eliminate traffic, and improve road efficiency through - Cordon System: fixed fee for All Vehicles that drive into a specific area M-F during peak times (e.g. London, Singapore) - Flexible Cordon system: Varying fees depending on vehicle type, time of day, location and direction travelled - Area-wide charges: per-mile charges on all roads within an area known for high-traffic rates - Car-free zones - Area licensing: driving only permitted to locals; permits are needed for everyone else (e.g. Milan) - High Enforcement (cameras)	>3	2	0 - 1
EMISSIONS TRACKING SYSTEMS	* GHG Inventory	Presence of a citywide inventory of all direct and indirect emissions from stationary energy, transportation and waste.	Yes	Yes	No
AIR QUALITY MEASUREMENT SYSTEMS	* Air Quality Index (AQI)	The AQI is an index of daily air quality reports stating what pollutants are in the air, how prevalent they are, and the overall air quality based on a scale of 1-500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. Our "HIGH" category of an AQI value of 0-100 represents good air quality, "MEDIUM" represents average air quality, and "LOW" represents hazardous air quality. The EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide.	0-100	100-200	<200
EQUITY	* Reduction Goals	Our research shows that most cities are reporting to the CDP. The CDP publishes a comprehensive list of all "A" cities with the highest reduction goals. Cities that don't qualify as A may fall under the "MEDIUM" category if they have action plans and goals but have not put enough actions to place to meet targets. Since many cities have rigorous plans, we defined a "LOW" criteria as not reporting to the CDP as an indicator for inadequate actions being taken.	>80% Reduction	50 - 79% Reduction	<50 to 0% Reduction

Figure 29b: Key Criteria Identified in the Maturity Framework

The Maturity Framework can be accessed here

Appendix 9: Model Guidelines

The model can be accessed here

Metric		Source
Last Mile Delivery Trip For LA (miles)	6.6	https://www.cbre.us/research-and-reports/US-MarketFlash-Last-Mile-Concept-or-Measurement
UPS 2018 Shipping Rate	$/lbs.	https://www.shipworks.com/blog/2018-ups-shipping-rates-start-on-december-24/
Average Distance of Last-Mile Delivery Each Year (miles)	13,116.00	https://afdc.energy.gov/data/10309
Operating Days Per Year	300.00	California Air Resource Board Total Cost of Ownership
Miles per Gallon of Delivery Truck	10.00	NGO Stringency Target Assumptions - May 9, 2014
Tailpipe Emissions per Gallon of Diesel (kg of CO2/gal)	10.39	EDF-NAFA Fleet Greenhouse Gas Emissions Calculator - October 25, 2011
Upstream Emissions per Gallon of Diesel (kg of CO2/gal)	2.47	EDF-NAFA Fleet Greenhouse Gas Emissions Calculator - October 25, 2011
Average kWh/Mile	1.4	https://theicct.org/sites/default/files/BYD%20EV%20SEDEMA.pdf
Total Output Emissions CAMX Subregion (lbs. of CO_2e/MWH)	498.7	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
Total Output Emissions NYCW Subregion (lbs. of CO_2e/MWH)	597.8	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
Average LCFS Credit Price ($/MT)	$134	https://ww3.arb.ca.gov/fuels/lcfs/credit/lrtweeklycreditreports.htm
Average LCFS Revenue ($/kWh)	$0.12	California Air Resource Board Total Cost of Ownership
EV Infrastructure	$16,357	California Air Resource Board Total Cost of Ownership
Maintenance Cost For Diesel Truck ($/mile)	$0.220	California Air Resource Board Total Cost of Ownership
Maintenance Cost For Electric Vehicle Truck ($/mile)	$0.017	California Air Resource Board Total Cost of Ownership
New York City Average Electricity Cost ($/kWh)	$0.220	https://www.bls.gov/regions/new-york-new-jersey/news-release/2018/averageenergyprices_newyorkarea_20180613.htm
Electric Vehicle Purchase Cost	$188,542	https://www.californiahvip.org/tco/
Diesel Vehicle Purchase Cost	$60,000	https://www.californiahvip.org/tco/
Sales Tax Rate	7.25%	https://www.californiahvip.org/tco/
HVIP Incentive (GVWR 14,001 - 19,500 in DAC)	$90,000	https://www.californiahvip.org/how-to-participate/#steps-to-participate
NYTVIP Incentive (Class 4-5 Vehicles)	$110,000	https://portal.nyserda.ny.gov/servlet/servlet.FileDownload?file=00Pt000000KtAw3EAF
Average Heavy-Duty Truck Emission (Carbon Monoxide)	1.176	https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EVY6.PDF?Dockey=P100EVY6.PDF
Average Heavy-Duty Truck Emission (NO_x)	4.45	https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EVY6.PDF?Dockey=P100EVY6.PDF
Average Heavy-Duty Truck Emission ($PM_{2.5}$)	0.084	https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EVY6.PDF?Dockey=P100EVY6.PDF
Average Heavy-Duty Truck Emission (VOC)	0.272	https://nepis.epa.gov/Exe/ZyPDF.cgi/P100EVY6.PDF?Dockey=P100EVY6.PDF
Total Output Emissions CAMX Subregion (lbs. of NO_x/MWH)	0.463	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
Total Output Emissions CAMX Subregion (lbs. of SO_2/MWH)	0.047	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
Total Output Emissions NYCW Subregion (lbs. of NO_x/MWH)	0.251	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
Total Output Emissions NYCW Subregion (lbs. of SO_2/MWH)	0.026	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
CAMX Subregion Grid Loss	4.80%	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
NYCW Subregion Grid Loss	4.88%	https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summary_tables.pdf
Payload Capacity of Class 4-5 Truck	up to 10,000	https://www.energy.gov/eere/vehicles/fact-621-may-3-2010-gross-vehicle-weight-vs-empty-vehicle-weight
Value of Avoided PM2.5 and NOx Emissions ($/MT)	$868,000.00	https://www.epa.gov/sites/production/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf

Appendix 10: Attributable emissions

Division of Emissions Scopes

Under the Corporate GHG Protocol, offsets are relative to a scenario where emissions would have been in the absence of a project.[155] A reporting company's Scope 3 downstream leased assets include Scope 1 and Scope 2 emissions of the leases.[156] Thus, the Virtual Delivery Emissions Model must establish parameters for allocating offset emissions to a specific owner to abide by internationally-recognized protocols and to avoid double-counting. The following is guidance on how these parameters should be established.

This model determines that a brand captures downstream Scope 1 and Scope 2 emissions from the carrier, which constitutes the carrier's upstream emissions from the volume and weight of packages and the electricity generated to power the EVs. These are counted as Scope 3 emissions for the brand.

The emissions avoided by switching out a carrier's diesel/gasoline-powered vehicle fleets are determined by 1) the difference between Scope 1 emissions from internal combustion vehicle fuel and 2) Scope 2 emissions from facility/charging electricity used for charging the EVs (indirect emissions from purchased electricity). The emissions avoided by the carrier here can be counted as Scope 1 emissions reduction since they own the EV.

Thus, if the brand capturing the GHG credit while the carrier counts the GHG emissions reductions against their baseline, there will be no double-counting. With the rights to the credit, a brand can use it to meet their own sustainability goals or sell it on the carbon market.

Certifying a carbon offset program and creating tradable credits

A project that finances the replacement of diesel/gasoline-powered vehicle fleets in downstream delivery operations constitutes a carbon offset program. It is a way for the brand to compensate for its emissions by funding an equivalent CO_2 saving elsewhere. For a last mile delivery project to qualify as an official offset project, it must be verified against international standards.

The Gold Standard recognizes initiatives that support community or institutional "end-use energy efficiency" as an eligible project. These projects can reduce energy requirements, such as gasoline and diesel fuel. Compared to their baseline scenario and opposed to no downstream emission reductions, "without affecting the level and quality of services or products" can constitute a "Community Service Activity" under the Gold Standard.[157] Under the standard's "General Eligibility Criteria", this project may fall under "(b) end-use energy efficiency", where it can be argued that the "physical intervention" is being had at the "user end" - being the last mile distributor.[158] Following a review by Gold Standard, this project could be certified as a Gold Standard project. Establishing this is contingent on the review through a review agency and may require alterations to meet compliance and receive approval.

If a brand seeks to participate in a tradable GHG credit market using the emissions reduced in this program, such as California's cap-and-trade program, then it must abide by the state or regional parameters for qualification. In theory, as a financier of offset emissions through EV deployment for last mile delivery, brands can claim a carbon credit per one ton of CO_2 avoided in their package being delivered by an EV in last mile distribution. This allows brands to receive an emissions-equivalent credit in the U.S., where available, that may be used to cut their Scope 3 emissions or trade on a carbon market.

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Appendix 10: Attributable emissions

Converting Offsets into Credits

Converting offset emissions into a credit is subject to strict rules that differ according to each state's individual program.[159] Under California's carbon-credit market, the Virtual Emissions Reduction Model will have to be developed in accordance with the California Air Resources board (CARB) and approved by Compliance Offset Protocols. The California Air Resources board will oversee the conversion of emissions reductions to ARB offset credits to be eligible for use in the state's Cap-and-trade program. The program proposed here would have to pass through an ARB-approved verification bod and thus abide by California's compliance offset protocols under AB 32:

- "The GHG emissions reductions achieved are real, permanent, quantifiable, verifiable, and enforceable by the state authority 38,562(d)(1));
- "Emission reductions are in addition to any reductions otherwise required by law or regulation, and any other emission reduction that would otherwise occur (38,562(d)(2));
- "Regulations governing the market-based mechanism maximize additional environmental and economic benefits for California (38,570(b)(3)); and,
- "Methodologies are adopted for the quantification of voluntary GHG emissions reductions that are authorized for use in complying with the state's GHG limits *38,571).[160]

In the case of New York, if the Virtual Delivery Emissions Model is established in a state jurisdiction under the Regional Greenhouse Gas Initiative (RGGI) for the purpose of generating offset credits outside the capped sector, then it must be recognized under one of five offset categories. Currently, this project does not abide by the parameters set forth by the five project categories for CO_2 offset allowances in New York state.[161]

As compliance offset protocols typically revolve around forestry, livestock, and ozone depletion projects, meeting the state's requirements is subject to an independent review that may not grant the approval of offsets earned under this program. All initiatives must be designed within legal to meet ARB protocols.

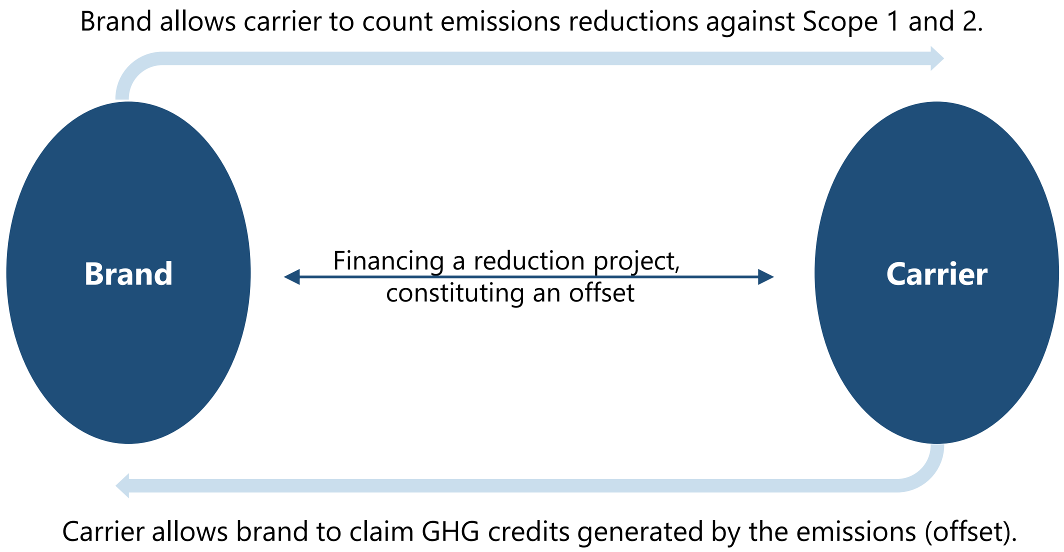

Figure 30: Carbon Credit Contract Example

Figure 30 illustrates how the contract between brand and carrier can be established for a structure that allows for a carbon credit to be generated without duplicity and in accordance with market regulations.

Appendix 11: Brand Offset Examples

Reformation

Reformation partnered with the Brazilian Rosewood Amazon Conservation Project and the Bonneville Environmental Foundation (BEF) for resource restoration projects. They have protected 1,000 acres of the Amazon rainforest from deforestation, contributed 27 million gallons of freshwater to California, and purchased several landfill gas offsets.[162] Reformation offers consumers the option to purchase bundles of offset projects. For example, they offer bundles to offset weddings, international or domestic flights, or an individual or a family. The climate credit purchase is done in partnership with Native Energy and verified by the Gold Standard.

United Airlines

United Airlines purchases carbon offsets on behalf of their customers in order to claim air travel with United Airlines is 100% carbon neutral. They also provide corporations with a tool to calculate the emissions from their employees' travels. In partnering with Conservation International, a reputable and responsible agency, United Airlines can show their customers exactly where their contribution is going.[163]

organicbasics.

Organic Basics operates on a similar model to United Airlines, where they provide consumers with the choice to purchase offsets on their website. By partnering with CHOOOSE, they are able to sell UN-verified, CO2 reducing projects in developing countries.[164] CHOOOSE also provides different options to choose from, such as "Individual 3 months Climate Credits" and "Family 3 months Climate Credits" which range from $12 to $45.[165]

Appendix 12: Interview Guide

In order to gather significant quantitative and qualitative data points to build our model, we identified stakeholders that could provide these insights and framed our interview questions based upon what information we needed to gather from them.

Brands

1. Are last mile deliveries a space that is currently being scoped?
2. What are the challenges with scaling last mile deliveries globally?
3. Have you seen any brands in the last mile space that could be modeled?
4. What would be necessary for you to partner with other Brands to address the last mile delivery space?
5. Amazon and UPS have announced investments in EV fleets, with goals to put 10,000 on the road by 2030. Do you plan to partner with carriers in the shift to EVs?
6. What types of incentives would encourage you to invest in EVs or form partnerships in the space?

Carriers

1. How are you looking to pilot EVs and which cities are you looking into?
2. Are you looking to partner with any brands to support the push for deliveries via EVs?
3. Has the program been fully scoped out? i.e. will there be additional charges? Would consumers have an option? Would this be a charge back to the consumer?
4. Are you planning to reach 100% deployment with EV? If so, how? Have you looked into consumer purchased offsets or carbon credits? If so, what do you imagine that looking like?

Sustainable Finance Professionals

1. What are the current financing mechanisms/structures in the EV space? To what extent do government subsidies/incentives matter?
2. Do you see PPAs playing a role in EV financing? Could offsets impact the space?
3. Do you think there is potential for EVs to monetize emissions savings in the form of RECs?
4. How do we calculate avoided Scope 3 emissions from last mile delivery via EVs instead of Diesel/ICE trucks and vans? Is there a basic calculation of 1 mile driven = X amount of emissions from Diesel/ICE trucks and vans?
5. How can we correlate Scope 3 emissions with Air Quality?
6. How can we calculate dollars saved based on the amount of Scope 3 emissions avoided? Dollars saved would be from avoided health risks, congestion, etc.?

EV Transportation Professionals

1. Has your research explored the deployment of EVs for last mile emissions reductions?
2. What can the U.S. learn from the EV market in China?
3. What financing mechanisms exist (e.g., green bonds. RECs) for purchasing EV fleets?
4. How can we account for EV emissions? Would they count as offsets?
5. Generally, how might you go about ensuring greater adoption of EVs within the private sector?
6. What are your expectations for the U.S. EV market, especially for large-scale commerce and distribution?
7. Are financial and infrastructure barriers to blame for holding back deployment at scale?
8. What kind of subsidies or other financial incentives are available in the U.S. to make EVs a more economical option?

Appendix 12: Interview Guide

GHG Inventory Specialists

1. What variables would you include in a model quantifying impacts on last mile emissions of distribution fleets? (e.g., total shipments; vehicle type EVs vs. petrol, distance of travel)
2. Have you done any quantification of companies that rely on multiple carriers? (e.g., Amazon using the USPS, FedEx, and UPS)
3. Is there a methodology for calculating those Scope 3 emissions and their subsequent mitigation via technology?
4. Do you know of any accounting and/or models that have built offsets into their quantification?

EV Manufacturing Experts

1. How is your team working with cities on implementing EV Infrastructure?
2. How is your team working with any cities on retrofitting for EV Infrastructure?
3. What types of challenges have you seen in the U.S. when it comes to implementing commercial EV's and Infrastructure?
4. What advice would you give to combat these challenges to make commercial EV's scalable.

Last Mile Ecosystem Knowledge Experts

1. What are the biggest hurdles you expect for Brands to enter the sustainable last mile space?
2. What are your expectations for the U.S. last mile ecosystem versus Europe’s or China’s? What are your speculations, if any, as to why the U.S. is trailing behind?
3. What kinds of incentives do you recommend to get a brand’s buy in for initiatives like EV last mile delivery?
4. To what degree do you think overconsumption needs to be addressed in conjunction with last mile delivery solutions?
5. If you could pick one city and/or one brand that you think is a model for best practice in this space, who would it be?
6. How do you foresee small businesses playing a role in these conversations, if at all?

Appendix 13: Interview Meeting Notes

Curtis Probst, Adjunct Professor, Columbia University
Co-CEO, New York City Energy Efficiency Corporation
February 25, 2020

1. **Do you know what financing mechanisms/structures are in place for EVs?** Would financing come from the carriers? It would help to think about if it would be a lease or another financing mechanism for the EVs.

2. **Do you see PPAs playing a role in EV financing? Could offsets impact the space?** E-commerce should pay carriers a certain amount each month for the EVs for certain revenue streams. (i.e. if they pay 10% increase in shipping costs). Find out the cost of EVs, O&M, packages we ship, packages per truck, and figure out how much it could cost brands to encourage carriers to do this. Who is owning and operating these EVs? First answer this to figure out who should finance. Figure out if brands have any fulfillment centers.

3. **What EV charging infrastructure do you think we will need?** We may need a surcharge necessary for the carriers to finance these. We need to figure out if fulfillment centers operate 24/7 and need to think about energy demand charges and electricity services at fulfillment centers. There is potential to add solar and/or battery storage system at fulfillment center to offset increased electricity use from EVs.

Dan Giuffrida, Adjunct Professor, Columbia University
Founder & CEO, Plankton Energy
March 1, 2020

1. **Is there progress on charging EVs with solar energy?** There is no progress on this, from what I know.

2. **What are some financing mechanisms you think are applicable to EVs to reduce last mile delivery emissions?** Companies can come together to be multiple off takers for a big utility-scale solar project that aggregates big corporations to become off takers to a large single-solar project. This model could potentially be applied from brands to EVs too. Level10 Energy is a firm that is doing this in the solar space. Fleet leasing is a mature financial market. The bank will provide financing and purchase the fleet. Cities could potentially own these EVs and lease them out to brands. In this case, cities would be the distributors. An option for cities to finance this is through green bonds and to enter a public-private partnership. I think two options as relating to solar financing are; 1) Buying all RECs as a company or as a group. 2) A virtual PPA. Paying for RECs and buying the energy, but someone else claims the RECs. This is risky with energy prices and double counting. Agree on market clearing price and the company pays the difference. These RECs need to be Green-E Certified.

3. **What are your key thoughts on this?** Offsetting until we have EVs makes sense from a financial standpoint. Cities can incentivize carriers to switch to EVs by providing tax credits or take the opposite stance and tax them on their emissions. It seems unlikely that brands will invest in purchasing EVs because they don't currently do their own last mile delivery and that is unlikely to change with the introduction of EVs. It is not just about switching to EVs but also the analytics and developing an efficient distribution system.

Appendix 13: Interview Meeting Notes

James Fine
Energy Research & Sr. Economist, Clean Energy, Environmental Defense Fund
March 4, 2020

How do we know we have an emissions benefit?

Vapor. Greenhouse gas pollution offsets. Verified emissions reduction through a project like avoided emissions or sequestration - there are registries of these projects and you can buy a commodity out of it. If you are doing this on a voluntary basis, this is a different set of standards in terms of voracity of emissions benefit opposed to compliance. With compliance offsets you have an emissions allowance and you can either reduce your own emissions, buy allowances from someone else or buy offsets. Vapor becomes important. Also it must be verifiable and additional (meaning are you taking credit for emissions reductions that would happen anyway. For example, if you put a cap on a landfill and capture methane, and we are flaring it, so we release carbon dioxide instead of methane and so we want a credit for that. But someone wonders if this is valid. What if the law says you have to cap your landfills. The offset then is not additional, permanent, enforceable (can you see it and enforce it) and real (overlaps a bit with additional. For example, utilities will give you a rebate for getting a new refrigerator that is more efficient, but what happens to that old refrigerator? Did you really reduce the load associated with that refrigerator if you just take it into your basement and plug it in. Another example would be a grant to replace a diesel truck with an EV. but what happened to that old diesel truck… is it in Mexico being driven now? If so, we did not get rid of emissions reduction.

If we are trying to get companies to make claims about offsetting pollution, we have to evaluate claims of emissions benefits against emissions acronyms. Once we have an offset, if we were talking about reduced pollution from the tailpipe of a vehicle and reduced criteria air pollutants (NOx and SOx and PM10), we could get direct air quality benefits because we are reducing particulate matter and benzenes that is unavoidably produced in an internal combustion engine. This is easy to calculate air quality benefit.

Fine particulate and ozone are not directly emitted from engines. If we reduce emissions from a long-haul truck (let's say in Houston), we know that Houston as a regional air base violates ozone standards so we would want to reduce ozone through strategies, but we do not have an ozone emissions factor for vehicles. Ozone forms when you add energy in the form of precursor pollutants to ozone (NOx and VOC).

We need to model change in emissions and change in atmospheric conditions. We could do this with a conversion using emissions factors for direct emissions but we need equations for the secondary factors. This could be problematic because it is Scope 3 but as long as brands are counting Scope 3 and acknowledge them, then it should be okay.

Appendix 13: Interview Meeting Notes

Crysta Jentile
Marketing Development, Greenlots
March 6, 2020

1. **What do you think is holding back EV deployment?** If you look at a fleet owner, it is impractical to replace their entire fleet in one go. The way fleet operators typically replace vehicles are all based on life-span and only a small percentage of total fleet at any time; not by replacing 100 percent at one time. For a fleet operator to replace vehicles that are in good condition or for them to manage vehicles using different types of fuel is expensive and logistically challenging. There are some different financing tools. There are leasing options and charging as a service, which a lot of companies offer to mitigate. Mobility as service offerings in cities is a hot topic right now. A city does not want to own cars (this is not their business) but if a company comes in and can offer them mobility as service cars it will allow them to lease an EV and charging infrastructure for a monthly fee and for a set amount of time. his is a great deal for the city since there are no worries about maintenance/budget, etc. Taxi/on-demand vehicle companies are also looking into this.

2. **Do you know of any instances where EVs are co-financed or shared?** I have not really seen this. My company is purchasing their own vehicles.

3. **What are some benefits of switching to EVs?** They have benefits other than reducing emissions. Since the delivery range of urban areas is small, it eliminates the range anxiety. My company is working with a carrier that has NYC broken out into 8-9 delivery zones; one truck might only drive 5 miles throughout a day and would delivery tens of thousands of packages within that 5 miles. Small, dense areas do not need as much charging as rural areas. Urban aspects make it easier and makes the infrastructure upgrades easier to deal with. In NYC, idling is a huge source of emissions. There will be no emissions from idling from EVs. NYC announced earlier this week to reduce idling emissions and are imposing fees. There could be a way to quantify how EVs will reduce idling emissions that could act as an incentive

4. **What advice do you have for us, as we proceed with our research and building our model?** It is fairly easy to work with fleets because there is so much data available from carriers around what their routes are, what their duty cycles are, when they have to be delivering packages, etc. Companies have information on their fleet vehicles, so it is a bit easier to map out required infrastructure, because you know where a car needs to be and when, and when it needs to go back to charge. Fleets have an advantage compared to cities who are planning for the public to adopt EVs. Because fleets can plan so efficiently, they can also reduce the level of charging that they need and can go with cheaper and easier (slower) charging than a city that has to plan for passenger vehicles needing to charge quickly to and from their destination. I recommend going towards the total cost of ownership route that helps calculate total cost of ownership for EV versus truck and breaks it down by light, medium and heavy. In terms of incentives, there is a tool through the DOE that tracks different incentives/rebates/tax laws for each state.

Appendix 13: Interview Meeting Notes

Jonathan Dickinson, Adjunct Professor, Columbia University
Practice Leader, Sustainability, Energy and Climate Change
March 8, 2020

1. **What variables would you include in a model quantifying impacts on last mile emissions of distribution fleets (e.g., total shipments; vehicle type (EVs vs. petrol); distance of travel)?** One important variable is electricity supply; when you start to model fuel switching from diesel/gas to EV, you will need to know the carbon intensity in the city (depending on the electricity supply). Another variable is GHG emissions, and you have to make some assumptions about each carrier in each city and what their current last mile delivery mechanism is. The number of last miles driven will be a variable. Brands can input the number of package. You should use the average last miles driven and look into their methodology, source Coldwell Banker Richard Ellis (CBRE). What you want to end up with, is a metric that can be applied based on the amount of goods (emissions/kg of product). You can use a weight or mass-based approach so it can slide depending on what is being shipped. You need to do a BAU analysis. Under current conditions, what are the GHG emissions per ton of cargo in each city for last mile deliveries? I encourage you to use average fuel-economy data that is available. Look at the Bureau of Transportation statistics and there should be something here that will give fuel use per mass of goods. You have to justify all this, using X liters of diesel fuel/ton of cargo and then that is our constant. Figure out what the flip side is with EVs as in how much electricity is used for the same delivery and what would be the equivalent fuel-switching impact. The math is very simple; x liters of diesel = y kg of GHG emissions and same thing with electric. Apply an electricity emissions factor depending on where the city is and use the EPA e-grid factor that is relevant for that particular city. There is a 2016 version but there might be a 2019 version. You can then see what is happening now and then what would happen for 50% or 100% EV deployment

2. **Have you done any quantification of companies that rely on multiple carriers (e.g., Amazon using the USPS, FedEx, and UPS)? Is there a methodology for calculating those Scope 3 emissions and their subsequent mitigation via technology?** You should leave this as a variable. Use the number of kg as the variable for each carrier and assume a constant for the rest (number of miles and the number of emissions).

3. **Do you know of any accounting and/or models that have built offsets into their quantification?** Brands cannot directly mitigate emissions with offsets. Scope 3 is downstream transportation and distribution and I am unsure if companies would purchase offsets for this type of activity. This would be more common in business travel because there is more concrete data and certainty. It is unlikely companies would break down emissions that specifically. If the brand purchases a REC, that would be applied to their own Scope 2 electricity use as opposed to Scope 3. Crediting it to Scope 3 does not make a lot of sense, and this is not proper accounting to say we are going to purchase a REC for Scope 3. Using a REC as an offset mechanism is clever accounting but starts to blur the lines. We have time to do more research here to see if this is pushing the line. Brands have the ability to control (to some degree) through contracting and partnering with carriers based on what type of fleet they use. Carriers are suppliers and are the downstream part of the brands supply chain. Brands have some influence here to pressure carriers to make a switch to EVs. I am currently working with upstream suppliers on incentives that can support initiatives through funding that can help the company reduce its own emissions and would have the ability to reduce Scope 3 emissions (embodied emissions in products).

Appendix 13: Interview Meeting Notes

Courtney Small
Sustainability Manager, Etsy
March 10, 2020

1. **What is your company's current sustainability strategy? Are funds being allocated to that strategy?** Etsy has a long history of incorporating sustainability into business strategy. The three overarching ecological goals that drive us are sustainable operations (waste and energy), Scope 3 emissions (invest in verified emissions reductions offsets for up to 98% of shipping emissions) and marketplace sustainability.

2. **Are you currently tracking Scope 3 emissions, specifically for deliveries?** Etsy is tracking these emissions and has committed to working with stakeholders to reduce emissions through electrification and route optimization. Etsy also advocates on the policy front that supports a sustainable transportation transformation using clout in the market to advance electrification. New York State is a big one.

3. **What are the challenges your brand/other brands faces in managing Scope 3 emissions?** There is just no control; this is an uphill battle for brands. It is easier on the advocacy side because there is a clear understanding of where advocacy is needed. Since Etsy has a long history of working on climate issues it is a natural fit. It gets complicated when Etsy cannot control who the sellers use (they primarily use one carrier); and brands may have better luck working with some carriers than others. Also it may be easier for carriers to invest in some areas and not others. This is a very early stage so it is hard to say what barriers we will face. For carriers, there are assumptions that a customer is interested in electrification. All carriers have some plans to electrify; carriers are basing where they choose to invest on variables that they don't have insight on. Opening up a conversation with carriers is most important right now. By starting a dialogue, we start to understand why both parties are interested and can come to a closer conclusion on where it makes sense to deploy—where there is infrastructure, where there is air quality initiatives and where there is funding.

4. **Would you be interested in partnering with other Brand?** There are a lot of opportunities for partnership because there really isn't a lot of activity right now.

5. **Amazon and UPS have announced investments in EV fleets, with goals to put 10,000 on the road by 2030. Do you see an opportunity for brands to partner with carriers in the shift to EVs?** There is a more natural tie between brands who control their supply chain.

6. **What types of incentives would be beneficial for you to partner with a carrier?** The project has changed since we originally discussed it. The main focus was on how to reduce those emissions. If you compare it to a PPA, there is a clear commodity for a brand to say, "I received this electricity and this REC and I own both of those things." Looking at a Level 10 model, if multiple brands could come together and have some sort of agreement where they can "subscribe" to a fleet of EVs and then potentially claim offsets based on how much the subscription is, it could possibly work. It is tough because with a PPA, you know how much electricity is produced and the way to account for that for EVs could be the amount of deliveries that happen during that month. It is not important to know that a package was on an EV truck but the virtual part of that still matters; the equivalent of my package is on some truck that I financed that is an EV truck. It will never be a 1:1, we will never know what trucks carry our packages.

7. **Would Etsy be interested in paying a carrier monthly to contract EVs?** We are thinking about a subscription model;. If there was a PPA for electrification of trucks, specifically last mile delivery trucks, can this be replicated and financially be interesting for brands? A PPA is not all about money, you get something back; something is transacted on behalf of the brands, which is important for an internal pitch. PPA is already a vetted model but is still difficult to pitch internally because it is not how electricity is typically purchased. There has to be an incentive that "closes the loop" that makes it a cycle. We have to define 1) what the price point is and 2) since this is not a carbon offset/REC and there is no market for this in EVs, so what would it look like? There is a policy in New York that is creating a market for EVs (similar to RECs) that I can share with you.

COLUMBIA UNIVERSITY
School of Professional Studies

Appendix 13: Interview Meeting Notes

Jason Mathers
Director of Vehicles & Freight Strategy, Environmental Defense Fund
March 11, 2020

1. **Do you have any insight into how the community solar model would work for EVs?** The functional-unit is something along the lines of package-miles traveled. We want to enable brands since they do not have enough capital. There could be a subscription model where you have an e-commerce apparel brand able to calculate how many parcel-miles they are consuming on an annual basis and then have a subscription or PPA with the fleet for that amount of zero-emission miles.

2. **Do you have any insight on how to calculate the dollar amount of that subscription?** The brands will not have access to those funds (subsidies, grants and tax incentives for trucks and chargers). Those are funds for the fleets. Even those funds are often insufficient.

3. **One thing we were looking at is talking to EV trucking companies to get information on the cost of the truck; all we have found is the cost of the Tesla semi-truck ($180,000) which we have been using as a proxy.** Last February, California Air Resources Board released a total cost of ownership analysis around their advanced fleet truck program (includes costs of many different trucks including the walk-in cargo van). Also, I can walk you through some of the assumptions used in the model EDF has. The CARB analysis is a pretty good starting place and likely the most robust. There are a couple other reports in the space but the CARB is where you should start.

4. **How can we account for emissions savings?** What is striking is we might be conflating two different pieces, the PPA versus the offset. From an accounting perspective, if someone has a PPA or is buying a lot of RECs, we assume that they are zeroing out a certain amount of energy that they are consuming. If that is the case, we could follow the same model for electric miles where you would calculate the number of parcel-delivery miles that you want zero-emission delivery miles and subtract that from the total parcel-delivery miles and calculate emissions for what is left. We have to understand how certain players have figured out how not to double count. There is a finite number of zero-emission miles and those will have to be allocated to different brands. We cannot have Brands accounting for 200 electric miles when really only 100 miles are being traveled. No one has done this in the transportation space but we have done it in the renewable energy space. We need to look at the protocols for PPAs/RECs and separate this from an offset. In my mind they are very distinct; offsets are something fundamentally different.

5. **How do we figure out the price of the truck and how many miles it is driving and then assign prices from there for savings?** We need to run a total cost of ownership for an electric truck and a baseline truck. Then we have to make assumptions about that LCA of the vehicle. It will be complex but it will give us a cost per mile for EV/diesel and the difference there should be how much a zero-emissions mile costs. The challenge is that it isn't just the cost per mile that matters to a carrier but also the payback; there will be a point where we have a lower cost/mile for electric vehicles but it will be a long ROI. We will have to do some discounting of those future benefits and make a lot of assumptions such as: how many chargers are in place and what the cost of electricity is.

Appendix 13: Interview Meeting Notes

Courtney Small
Sustainability Manager, Etsy
March 19, 2020

1. **We couldn't find a good metric for a truck but found good sources on electric vehicle passenger vehicle to calculate cod per mile per electric vehicle truck. We calculated emissions tons: emissions offsets is about 44 tons per year/ based on assumptions we had. This could change on total weight of packages.** I can see if anyone knows an electric vehicle heavy duty factor.
2. **We narrowed down our pilot city to LA because of incentives. What are your thoughts on that?** I understand the benefits of LA but is there a way to compare both LA and NYC? We are not set on LA and are looking into NYC too because there is so much going on here. It would be helpful to do a comparison to decide which city to focus on first. Regarding the fuel standard treaty mechanism: we can advocate for these mechanisms as much as possible. We might start with LA, but if we could do it in NYC then it makes a more compelling case.
3. **What are your thoughts on the model and recommendations thus far?** What could be interesting is if Etsy had 10 pounds on 1 truck and eBay has 30 pounds on that truck and we have an accounting of pounds per month instead of an upfront allocation. We then let it accrue overtime. We don't have to make an assumption about our weight in the future and pay upfront. With eBay and Etsy, there is nuance because we don't ship packages, the marketplace does.
4. **We are unsure how to avoid double counting: what would that look like? If carriers claim this as scope 1, can brands also claim this as scope 3?** If FedEx was the main carrier we used, then all of FedEx shipping is our scope 3 and their scope 1. If they move to EV, then both of these scopes are reduced.
5. **What are your thoughts on a lease-based model?** We would never lease a vehicle but maybe there would be the purchase of offsets for the benefitting brands. Look up forest resilience bond. As air pollution is an incentive to certain parties, this could add to benefits. There is another way to get payments for air quality reduction.

Jen Roberton
Senior Transportation Policy Advisor, NYC Mayor's Office
March 26, 2020

1. **What do you think of New York as a pilot city?** In NYC we are piloting cargo bikes: For us it begs the question - what does it look like not to have the truck as mobile storage? Trucks store packages for dirivers, at times overnight. Are we looking at a mobile grocery store like Fresh Direct? What does it look like with delivery time?

2. **In response to model:** It is good to know you got similar conclusions in your model. The main difference is the kWh rate being so much higher in NYC, and we need more assistance for fleets. We are looking at Charging as a Service models. Charging as a service provides fleet price guarantee with the developer managing the utility bills.

Appendix 13: Interview Meeting Notes

Jason Mathers
Director of Vehicles & Freight Strategy, Environmental Defense Fund
March 20, 2020

1. **The handbook was focused on Class 8. Is there any concern regarding the numbers from CARB?** CARB has some optimistic numbers; 24,000 miles jumps out as a bit high. The number that I was using was from Oak Ridge Alternative Fuel Data Center and is only 13,116 miles, which is probably a better starting assumption, especially with current technology for EV (these vehicles will be at the low-end for annual miles).

2. **We also used the 161.80 grams of CO_2 per ton mile from the handbook as the average for all heavy-duty trucks. We were having trouble finding specific emissions factors. Do you have any advice on this?** The best way of going about this is to develop an MPG number; calculate fuel consumption (distance/MPG) to get total gallons. Then come up with the amount of fuel being consumed and apply an emissions metric per gallon. This method does not rely on vehicle type and there is more availability to adjust. A more accurate way is to calculate the amount of fuel you would burn and then use that fuel coefficient.

3. **Do you have any advice on finding emissions from an EV step van?** I recommend taking the approach where you make an assumption about how many kWs are consumed per mile. I can send you some data on this and a calculator I developed a year ago assumed 1.4 kWs per mile. We could calculate how much energy that vehicle consumes and then we apply an electricity coefficient specific to the geography that we are operating in with an E-grid from EPA (emissions/kWh). This is a flexible way to adjust because 1.4 kW/mile is probably a conservative number given current technology. If we build the model around that assumption, we can tweak it. We can double check assumption to determine what it looks like on a daily basis and then determine how much time it would take to charge.

4. **In response to cost/pound/year PPA Model:** It takes into account incentives and CARB. Since it costs less on a per pound basis, a coalition of Brands could work with a Carrier to contract a rebate per pound and get a credit. This would develop a PPA model. A carrier puts up the upfront capital and gets back some of the investment by charging carriers. There is a whole industry that is about negotiating with parcel carriers. Within the last year or two there has been a movement (density potentially) on a new formula that is more volumetric than weight based.

5. **Leasing Model**: In this model you can sell credits on the cap and trade program to reduce lease payments. This model has a lot to offer; what jumps out to me is as I understand the LCSF credit, it goes to the fuel provider. In order for the fleet to be the fuel provider, the fleet needs to own its own charging infrastructure and the cost of the infrastructure is expensive. The assumption is the infrastructure is not included in the lease price. We might not be able to model that fixed cost. We have to confirm if the EV fleet provider would be providing the infrastructure and determine if the LCSF credit can be applied to the brand.

Appendix 13: Interview Meeting Notes

Bill Loftis
Senior Director of Integrated Solutions, Transportation Insight
March 27, 2020

1. **Could you shed some light on how the relationship between brands and carriers and how it is evolving?** In the world of parcel carry, there were only a few national carrier. Brands typically have three-year contracts with a carrier. A contract is a big deal and it can take as long as a year to work out one. E-commerce is changing the supply chain. Historically, a chain was an appropriate metaphor (materials flowed from link to link); but in the last 5 years, with eCommerce, it's more like a web. Inventory can now be shipped directly to a consumer and originate anywhere: from a vendor, distributor, store, warehouse, and so on. Orders can be fulfilled from anywhere in the ecosystem, which makes optimization more complex. From a carrier perspective, there are now more players. Regional carriers began as mom and pop shops and now they are growing, trying to evolve their technology, so with Regional' brands have gained flexibility. They might be able to break from the traditional 3-year deals. These deals are frequently adjusted – by the carriers - with new pricing policies, which allows proactive brands to refine carrier choices appropriately. Sophisticated parcel carrier pricing models are an important capability for brands to constantly optimize carrier selections in their networks.
2. **As incentive for EVs, if the price/lb. were lowered, would it be cheaper to run an EV? Would they change their pricing based off that?** It could potentially be cheaper, because it's a competitive market. They charge on a per/lb. basis anyway. Pricing generally follows a matrix: they are contracted for a rate/package shipped as a function of lbs. per package by "zone" travelled. Zones are defined by shipping point, and vary. It is a county by county (or zip by zip) structure of the U.S. A zone 2 is closest (typically within ~150 miles), zones 3-6 are further out. Zones are probably based on the density of their network. Density and the number of packages per drop-off are very important profitability variables for the carriers. Within the U.S. there are 5 zones and a "Rate Card" similar to an excel matrix shows lb./zone pricing. So to answer the question, weight is part of the mechanism. Carriers also typically do not use specific trucks for certain brands; packages from multiple shippers are co-mingled as they flow through the carrier hubs.
3. **What about a lease- based model?** I am not sure about that. If you can introduce another entity that can take on vehicle ownership, it could be less of a burden for them.
4. **Do you have any other insights we could take into consideration when building our model?** I have spent a lot of time with e-commerce and there are many fluctuating variables on the cost side of this equation including the varying price of gas. There are so many variables, costing is so complex that cost comps alone won't be enough to find sustainable eComm solutions. Shippers (retailers) want market penetration and sales and that's another way to solve this problem. So, suppose a brand focused on its sustainability leadership (such as supporting EV), and increased sales, then others might follow and we'll have more EV's and more sustainable outcomes. So while cost is important, and we should show it is cheaper, I doubt winning the cost battle will get us to our goal. Also, although EV is a big sustainability factor, there are many other elements of a sustainable e-commerce supply chain solution. Controlling inventory – the new complexity in the supply web – is incredibly important. Sustainable solutions must position inventory close to customers: eliminate long zones, air, and multi-sourced orders. Improved inventory control will support both sustainability and improved retail profitability.

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