Clean Fleet Transition Plan

NYC Department of Citywide Administrative Services (DCAS) Fleet

U.S. DOT Volpe National Transportation Systems Center: Alexander Epstein, Ph.D., Scott Lian, Ana Vargas, Andrew Breck, and Brian Xi

New York City Department of Citywide Administrative Services: Keith Kerman and Eric Richardson

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- Business Integrity Commission (BIC)
- Department of Environmental Protection (DEP)
- Department of Correction (DOC)
- Department of Education (DOE)
- Department of Education Pupil Transportation
- Department of Health and Mental Hygiene (DOHMH)
- Department of Transportation (DOT)
- Department of Parks and Recreation (DPR)
- Department of Sanitation (DSNY)
- Fire Department (FDNY)
- New York City Housing Authority (NYCHA)
- New York Police Department (NYPD)
- Office of Chief Medical Examiner (OCME)
- Office of Emergency Management (OEM)
- Sheriff's Office

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List of Abbreviations

Abbreviation	Term
APU	Auxiliary Power Unit
ANL	Argonne National Laboratory
BEB	Battery Electric Bus
BEV	Battery Electric Vehicle, i.e. All-Electric
BIC	Business Integrity Commission
CFTP	Clean Fleet Transition Plan
CNG	Compressed Natural Gas
DCAS	Department of Citywide Administrative Services
DCFC	Direct Current Fast Charge(rs), which requires 480 volts and can replenish 120-160 miles of range per hour
DEP	Department of Environmental Protection
DOC	Department of Correction
DOE	Department of Education
DOHMH	Department of Health and Mental Hygiene
DOT	Department of Transportation
DPR	Department of Parks and Recreation
DSNY	Department of Sanitation
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment (i.e., charging station)
FDNY	Fire Department
GVWR	Gross Vehicle Weight Rating
HD	Heavy Duty
HDV	Heavy Duty Vehicle
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
Lbs.	Pounds
LD	Light Duty
LDV	Light Duty Vehicle
Level 2	Refers to a Level 2 charging station, which requires 240 volts and replenishes 10-20 miles of range per hour
MD	Medium Duty
MDV	Medium Duty Vehicle
NYC	New York City
NYCHA	New York City Housing Authority
NYCSBUS	NYC School Bus Umbrella Corporation

Abbreviation	Term
NYPD	New York Police Department
OCME	Office of Chief Medical Examiner
OEM	Office of Emergency Management
PHEV	Plug-in Hybrid Electric Vehicle
SFTP	Safe Fleet Transition Plan
SUV	Sport Utility Vehicle
UTV	Off-road Utility Task Vehicle
Volpe	U.S. Department of Transportation John A. Volpe National Transportation Systems Center

Executive Summary

The New York City Department of Citywide Administrative Services (DCAS) is formalizing its investment in vehicle electrification and emission-reducing strategies for all fleet vehicles by adopting a Clean Fleet Transition Plan (CFTP). The CFTP provides a roadmap to eliminating the tailpipe emissions that contribute to climate change and toxic air pollution, in direct support of Mayoral Executive Order 90 of 2021, mandating accelerated fleet electrification by 2040 for all fleet units as outlined below:

- 2030 for non-emergency light-duty vehicles (LDVs);
- 2035 for remaining light-duty (LD), all medium-duty (MD), and non-emergency heavy-duty vehicles (HDVs);
- 2040 for specialized and emergency trucks if there are no electric models available sooner.[1]

Consistent with Mayoral Executive Order 53 of 2020, the CFTP can also inform the efforts of other public and private fleet operators in New York City and beyond to make similar electrification and clean fleet transitions.[2] Executive Order 53 charges DCAS with educating and advising public and private fleets as they transition to safe and electric Fleets of the Future. This document is part of that effort.

This first edition of the CFTP discusses the existing progress of City agencies in electrifying fleets and using interim emission reduction technologies, the availability and readiness of electric vehicles (EVs) for operation in agency fleets, and strategic considerations for the transition to all-electric as well as intermediate measures.

The U.S. Department of Transportation Volpe Center's (Volpe's) analysis of the DCAS fleet roster of nearly 29,500 fleet units finds that existing vehicle electrification varies significantly by agency.

Volpe discussions with City agencies revealed both opportunities and challenges related to fleet operational needs, charging infrastructure needs, and current experience with EVs and other technologies:

Opportunities

- Approximately 400 city fleet non-emergency sedans are currently not electric or plug in and can be replaced with electric models now as vehicles reach end of life cycle.
- Cargo vans, smaller pickups (F-150 and below), and passenger vans and buses not used for emergency services or law enforcement are a prime segment for electrification. Approximately 2,100 city fleet vehicles of these types could be converted to all-electric now, subject to current vehicle life and usage.

[1] https://www1.nyc.gov/assets/dcas/downloads/pdf/fleet/executive_order_90_accelerating_electric_vehicle_adoption_for_nyc_fleet.pdf

[2] https://www1.nyc.gov/assets/home/downloads/pdf/executive-orders/2020/eo-53.pdf

- DCAS plans to ensure that contracts are in place to electrify vehicle types that can be electrified within the next five years. Multiple agencies report idling their vehicles to power auxiliary equipment that could run cleanly off an EV battery.
- Garbage trucks that do not perform plowing functions are more suitable for short-term electrification than plowing units.
- Downsizing vehicles to smaller platforms, such as from sport utility vehicles (SUVs) to sedans or crossovers, can make it possible to electrify those fleet units sooner due to the greater market availability of smaller EVs, with potential efficiency and safety benefits.
- First responders and emergency services report a need for charge times under 30 minutes, while most other agencies did not report this as a priority.
- Interim fuel efficiency solutions are concentrated among agencies with specialized heavy-duty vehicles (HDVs) that are not currently electrified.

Challenges

- All agencies perceive an overall shortage of charging stations. DCAS can address this by installing additional chargers and ensure agencies are aware of current charging capacity.
- Plug-in hybrid electric vehicles (PHEVs) are popular among multiple agencies that have started electrifying their LD fleet, but not all agencies are consistently charging them.
- Some agencies with heavy-duty (HD) trucks report hesitance to test new BEVs and prefer non-plug-in hybrid electric vehicle (HEV), EV retrofits, or renewable diesel solutions.
- Some agencies report cargo space needs to transport specialized equipment and foresee challenges with downsizing certain vehicles if doing so reduces the cargo space.
- As electrification expands, there will be a growing need for resilient charging solutions including backup power options in case of power outages.
- The capacity for electric vehicles to plow and to operate off-road with four-wheel drive are operational concerns.

Volpe, in partnership with DCAS, has defined three EV market-readiness *Tiers* and mapped these Tiers to the vehicle categories represented in agency fleets, including a comprehensive analysis for on-road vehicles and a preliminary analysis for off-road vehicles. Note that the Tiers only represent publicly available information on market-readiness and do not account for current or future constraints associated with available charging infrastructure. External supply chain factors, including chip and battery availability and manufacturer delays, could impact these timetables, as could budgetary decisions impacting NYC Fleet acquisition replacement cycles and contractual terms and conditions.

The Tiers provide a vehicle-side transition planning tool based on expected market availability within 0-3 years for Tier 1, 3-5 years for Tier 2, and greater than 5 years for Tier 3. **Volpe, in conjunction with agency fleet managers and based on additional fleet unit analysis performed by DCAS, found that EV options exist now or are likely to exist within 5 years that cover 84 percent of the City's owned on-road fleet. For the remaining 16 percent, consisting mostly of public works and emergency trucks, including plow garbage trucks, DCAS plans to work with manufacturers to develop and test suitable offerings.** Table 1 summarizes the market-readiness tiers for the most common vehicle categories, and

Section 3 of the report provides supporting detail. The appendix of this report provides a full mapping of all DCAS vehicle standard types to each tier. Selected example vehicles are representative of Volpe market research based on public information and are not an endorsement of any product or company. Actual DCAS vehicle acquisitions are subject to DCAS public bidding requirements.

Table 1: Tiered Technology Availability for Common Vehicle Categories with Examples

Tier	Vehicle Categories	Selected Example Vehicles (***Retrofit Solutions in Italics***)
Tier 1	LD Class 1 and 2a: cars, pickup trucks, passenger, and cargo vans.	**Sedans**: Tesla Model 3 (Police version available) MB EQS; **Hatchbacks**: Chevy Bolt (Police version available), BMW i3 (Police version available), VW ID.4, Hyundai Kona, Nissan Leaf, MINI Cooper SE, Polestar 2; Jaguar I-Pace; Porsche Taycan; **Crossovers**: Ford Mach E (Police version available), Audi e-Tron, Hyundai Ioniq, Kia Niro, Tesla Model Y, Tesla Model X **Pickup trucks**: Rivian R1T, Ford F150 Lightning, Silverado EV, Tesla Cybertruck **Passenger / cargo vans**: Ford Transit Connect, *Lightning eMotors Ford Transit passenger van*
	LD Class 2b: passenger and cargo vans.	**Passenger / cargo vans** (all w/ dedicated chassis): Ford e-Transit, *Lightning eMotors Transit Passenger Van*, Brightdrop EV600
	MD Class 4-6: common work truck platforms (F450/4500, etc.) that underpin different bodies including shuttle & school buses, step vans, delivery vans, box trucks, and ambulances.	**Shuttle buses, school buses, step vans, delivery vans, box trucks**: *New EV upfit of popular MD truck chassis: Collins Bus Corporation (Type A school bus / F450) Lightning eMotors (multiple chassis and body types), Motiv Power Systems (multiple chassis and body types), Phoenix Motorcars (Ford F450/F59 chassis)*; Lion Electric low-floor shuttle bus (Lion M – dedicated chassis) Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6 **Type II and III ambulance**: Demers eFX (dedicated chassis)
	HD Class 7-8: transit and school buses, fire apparatus, and collection trucks.	**School buses:** Blue Bird (Type C&D), BYD, IC Bus (Type C), Lion, Thomas Built (Type C w/ Proterra system), **Transit buses**: BYD, ENC (El Dorado National), Gillig, New Flyer, NOVA, MCI, Proterra **Collection trucks**: Mack LR Electric, BYD 8R, Lion8
Tier 2	LD Class 1 and 2a: minivans, SUVs (Consumer & Police).	**Minivans**: Mercedes Bens EQV, Chrysler Pacifica EV, Canoo **SUVs**: Rivian R1S, Ford Explorer, Chevy Tahoe
	LD Class 2b/3: SUVs, cargo vans and pickup trucks	**SUVs**: Ford Excursion EV **HD Pickup Trucks**: Ford Lightning HD, Chevy Silverado HD **Cargo / passenger vans**: Bollinger Deliver-E, Mercedes Benz e-Sprinter *Note: NYPD vans and buses are currently Tier 3
	MD Class 4-6: work trucks (and subsequent body types incl. shuttle, vocational, fire, ambulance (type 1), etc.)	**Work trucks and Type I Ambulance**: *Dedicated chassis, not upfits.* Zeus Electric Chassis; Bollinger Work Truck Chassis
	HD Class 7-8: collection trucks for plowing	Not currently available, requires enhanced energy management and/or increased density to accommodate extended, continuous use

Tier 3		in cold temperatures. DCAS to test 7 BEV garbage trucks for plowing function.
	HD Class 8: fire ladder trucks	Not currently available; Rosenbauer announcement for 2023 in European market **Fire pumper apparatus**: Models announced but unclear whether they match NYC requirements (Pierce Volterra, E-ONE Vector, Rosenbauer)

Volpe analysis finds that 41 percent of existing on-road agency vehicles are in a Tier 1 category and can be prioritized for the transition to BEV either immediately or within three years. See Figure 1. These vehicles include cars, LD pickup trucks, passenger and cargo vans, non-plowing collection trucks, school and transport buses (except the New York Police Department (NYPD), Type 2 and 3 ambulances, and mobile command centers.

Another 43 percent of all agency vehicles fall under Tier 2 and could be electrified in three to five years, based solely on expected EV market availability. Tier 2 includes police and non-police SUVs, Type 1 ambulances, minivans, and heavier pickup trucks.

The remaining 16 percent of vehicles that are in Tier 3 are expected to not be market-ready for electrification within five years, including collection trucks used for plowing as well as fire ladder trucks and pumper trucks. Given the longer lifecycle of these HD fleet units, other interim emission reduction measures, such as renewable fuels, will be important to still advance toward the City's emission fleet targets.

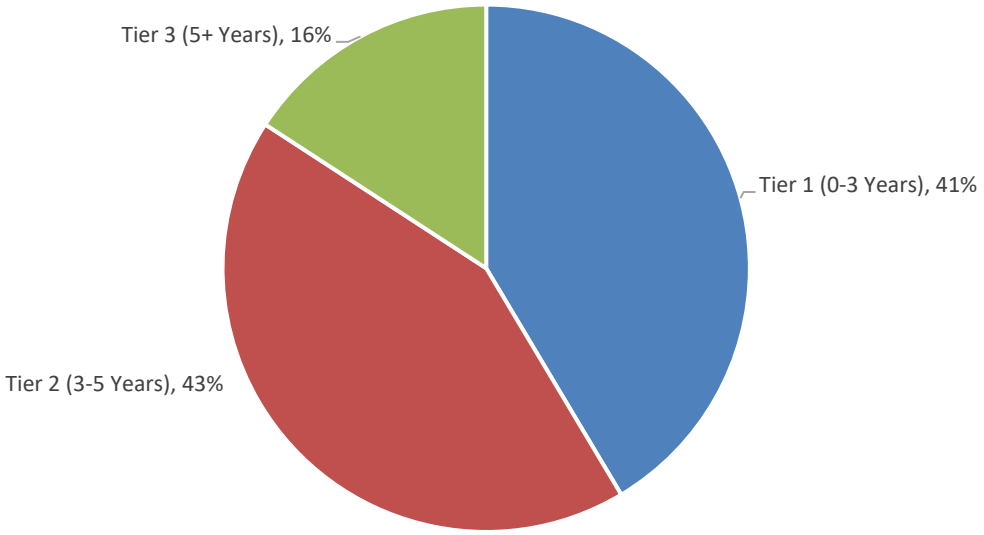

Figure 1. Percent of On-Road NYC Fleet Units by Assigned CFTP Tier

Separate from the on-road vehicles discussed in prior sections, about 15 percent of the City'sfleet consists of fueled off-road and specialized equipment. Volpe's preliminary market-readiness tiers analysis finds that 15 percent of these fleet units currently have or will have models available within three years and another 66 percent are expected to have electric options within five years, as shown in Figure 2.

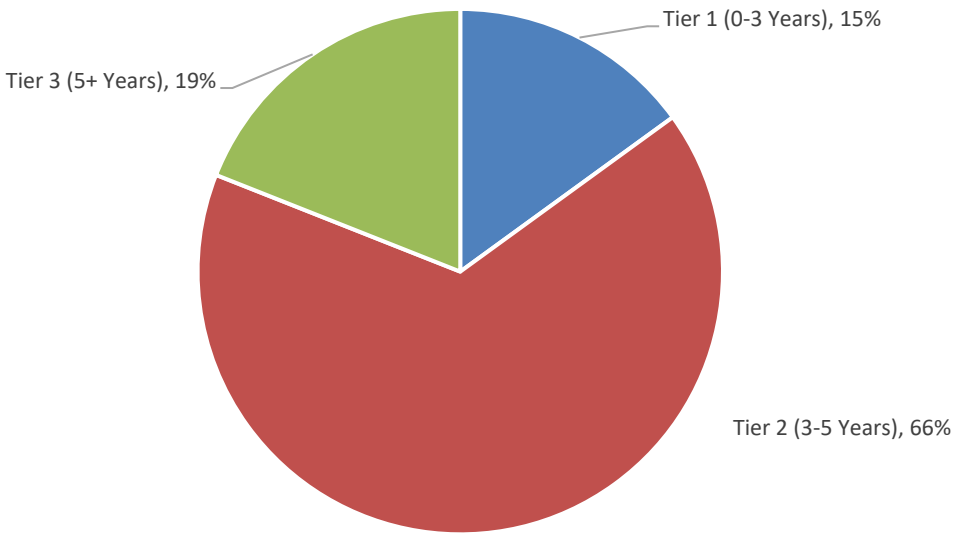

Figure 2. Percent of Fueled Off-Road NYC Fleet Units by Assigned CFTP Tier

The City's transition to zero emission vehicles is likely to be a complex, long-term undertaking that will require considerable flexibility in contracting, procurement, and where possible, funding sources and availability. This report identifies nine strategic considerations, including opportunities as well as potential constraints and caveats.

At a high level, successfully transitioning a fleet to all-electric must accommodate many factors, and not solely vehicle availability. DCAS may need to consider the daily use of individual vehicles, the operating environment, electricity rates and grid capability, operational functionality, time periods available for charging, and other factors, to understand which vehicles can be replaced without affecting service and performance. Given the strong demand for EVs, certain EV models' supply initially may not keep up with demand. Such market conditions could delay DCAS's ability to acquire certain EV models as soon as they come to market. Some phase-in flexibility may be needed within the boundaries of fleet buying cycles and DCAS's procurement rules.

Two key enabling strategies that Volpe has identified include:

- Vehicle downsizing to smaller vehicle platforms based on segmentation by usage requirements, including downsizing from SUVs to passenger cars and/or crossovers and from large pickups to

LD pickups, to accelerate electrification wherever possible and to realize other efficiency and safety benefits; and,

- City driver education about new best practices that will help maximize the range and longevity of electric fleet units, such as heating the passenger, not the cabin, or using regenerative braking instead of unnecessary harsh braking.

Three additional strategic considerations that Volpe will analyze further prior to the next CFTP include: planning and implementing the right types and quantities of charging infrastructure, or electric vehicle supply equipment (EVSE); the safety-sustainability interaction of Safe Fleet Transition Plan (SFTP) and CFTP technologies; and planning for end-of-life disposal for BEVs.

1 Introduction

1.1 Background and Purpose

The New York City Department of Citywide Administrative Services (DCAS) operates the largest municipal fleet in the United States, with nearly 29,500-vehicles, including 120 types of on-road equipment pieces and an additional 71 off-road unit types. DCAS has implemented over 20,000 fleet units that use electric, hybrid, biofuel, or solar power, including 4,050 electric vehicles (EVs) and 1,270 charging ports at time of writing. This may be the largest alternated fuel powered fleet in the United States currently. In Fiscal Year 2022, DCAS ordered 1,,350 EVs and has begun installation of over 600 additional chargers. DCAS anticipates installing 1,776 fast chargers by 2030. The Mayoral Executive Order 53 of 2020 calls for DCAS to publish Clean and Safe Fleet Transition Plans (CFTPs and SFTPs) to outline in detail its plans to achieve these ambitious sustainability commitments. The CFTP formalizes a set of vehicle electrification and emission-reducing strategies for all fleet vehicles to eliminate the tailpipe emissions that contribute to climate change and toxic air pollution, in direct support of a series of mayoral executive orders mandating accelerated fleet electrification. The Mayoral Executive Order 90 of 2021 has accelerated the transition to an electric fleet from the previous target year of 2040 to:

- 2030 for non-emergency light-duty vehicles (LDVs)
- 2035 for remaining light-duty (LD), all medium-duty (MD), and non-emergency heavy-duty vehicles (HDVs)
- 2040 for specialized and emergency trucks if there are no electric models available sooner.[3]

According to DCAS, at least 84 percent of the fleet will now transition to electric by 2035.[4]

DCAS has partnered with the U.S. Department of Transportation John A. Volpe National Transportation Systems Center (Volpe) to conduct research in sustainable and safe fleet options and to prepare these reports. In partnership with Volpe, DCAS has published four Safe Fleet Transition Plans. This is the first CFTP produced under Executive Order 53.

Volpe partnered with DCAS to research vehicle electrification and interim emission-reducing technologies and to develop best practices to accelerate the transition. Like the Vision Zero safety-focused Safe Fleet Transition Plan (SFTP) that DCAS adopted in 2017, the CFTP characterizes technology availability and readiness in a three-tier framework for the major categories of City fleet units. The emphasis is on transitioning to an all-electric fleet, focusing on battery electric vehicles (BEVs), including non-plug-in hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs) as intermediate

[3] https://www1.nyc.gov/assets/dcas/downloads/pdf/fleet/executive_order_90_accelerating_electric_vehicle_adoption_for_nyc_fleet.pdf

[4] https://www1.nyc.gov/assets/dcas/downloads/pdf/fleet/NYC-Fleet-Newsletter-374-December-23-2021-Mayor-Announces-Major-Acceleration-of-Fleet-Electrification.pdf

steps, rather than vehicles that run solely on liquid or gaseous fuels.[5] The CFTP technologies that reduce fleet emissions can also affect fleet safety and, similarly, SFTP safety technologies can also affect vehicle fuel consumption and emissions. For example, high vision trucks are well suited to electric models. Alternatively, electric vehicles are heavier due to the batteries than their fuel powered counterparts. Both issues can impact safety. Future Volpe analysis will focus on this nexus between Vision Zero and the electrification transition.

Accelerated progress in reducing emissions will depend on cross-agency communication, agency willingness to pilot new technologies, close coordination with private industry including vehicle manufacturers and suppliers, and regular revision of the CFTP itself. As technologies for fleet electrification and emission reduction evolve rapidly, DCAS will review and revise the CFTP at least biennially in conjunction with the Fleet Federation agencies.

1.2 Methodology

The report analysis starts with summarizing existing conditions at City agencies, in terms of electrification and interim emission-reducing technologies for fleet vehicles, based on agency interviews and fleet inventories from September 2022. Section 2 provides more detail on the method and findings for that portion. The analysis then progresses, in Section 3, with research to identify electrified versions for every existing vehicle type inthe citywide fleet. This involved classifying the existing inventory into major vehicle types, classifying availability by defining three Tiers, and then assigning a Tier to each vehicle type based on the timeline for commercial availability. Section 4 of the analysis describes some overarching considerations relevant to fleet electrification and clean fleet procurement. The information contained is current as of the publication of this report. However, the landscape of electrification–including vehicle offerings–can and will change significantly over the coming months and years.

2 Agency Baseline Findings

To research and develop preliminary findings, Volpe met independently with 15 City agencies that will play a key role in the clean fleet transition. The goal was to understand each agency's current fleet roster and their efforts to electrify the fleet, paying particular attention to:

- Operational needs;
- Charging infrastructure needs and challenges;
- Adoption of and experience with EVs and other technologies;
- Perceptions of EV attributes including but not limited to range, winter weather capability, comfort, and reliability; and,
- Other factors mentioned by the agency.

Each meeting involved Volpe staff and one or more fleet representatives for that agency. Agency perceptions of their ability to electrify vary, and the meeting notes and observations are strictly based on these. The Volpe team did not take into these discussions any documentation or information about what DCAS is working on in relation to these topics. General interview findings have informed some DCAS follow-up with these agencies.

Interviewed fleet operating agencies include:

- Business Integrity Commission (BIC)
- Department of Environmental Protection (DEP)
- Department of Correction (DOC)
- Department of Education (DOE)
- Department of Education Pupil Transportation
- Department of Health and Mental Hygiene (DOHMH)
- Department of Transportation (DOT)
- Department of Parks and Recreation (DPR)
- Department of Sanitation (DSNY)
- Fire Department (FDNY)
- New York City Housing Authority (NYCHA)
- New York Police Department (NYPD)
- Office of Chief Medical Examiner (OCME)
- Office of Emergency Management (OEM)
- Sheriff's Office.

These discussions were conducted without DCAS participation. Beyond the notes produced during these meetings, Volpe also had access to the City's fleet-wide vehicle roster, with agency, make, model, vehicle type, and other attributes. This, alongside other agency-specific fleet rosters, when available, informed the content in Table 2 and Figure 3 in this section.

Agencies' vehicle needs were largely dictated by their respective operations. Whereas some agencies were more administrative in nature, requiring only LD non-emergency sedans, other agencies responsible for passenger transport or vocational operations required larger vehicles with specific functionality. There were significant differences within agencies and vehicle types based on use. For example, the Sheriff's Office use of sedans and SUVs varied widely across divisions within the Sheriff's Office.

2.1 Current strategies and progress by agency

Table 2 summarizes the electrification and emission-reducing strategies each agency is pursuing, as reported by those agencies during the interviews and given their knowledge at the time. DCAS has implemented additional initiatives during 2022 including a large Mach E procurement for law enforcement and other agencies as well as a pending purchase of over 300 electric cargo vans. DCAS ordered 1,350 EVs in Fiscal Year 2022. These units are not included in this assessment unless deliveries have been made and vehicles are in active service. Figure 3 presents the composition of each agency's fleet by fuel type. Volpe's analysis of the DCAS fleet roster of over 29,500 fleet units indicates electrification by agency varies significantly, with three agencies exceeding a 10 percent share of BEVs, while seven agencies are below 5 percent electric share, as of the roster publication. Including PHEVs, however, one agency fleet is already majority plug-in. Note that these figures only represent the agencies that were interviewed.

Table 2. Electrification and Emission Reduction Strategies Reported by Agencies in Summer 2021

STRATEGIES:	BIC	DEP	DOC	DOE	DOHMH	DOT	DPR	DSNY	FDNY	NYCHA	NYPD	OCME	OEM	Sheriff
Hybridization and Electrification	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Engine/Fuel Technologies			✓	✓		✓	✓	✓	✓	✓		✓	✓	
Tire Technologies			✓				✓					✓		
Idle Reduction Technologies						✓	✓	✓	✓			✓		
Operational Approaches	✓	✓	✓	✓	✓	✓	✓		✓				✓	

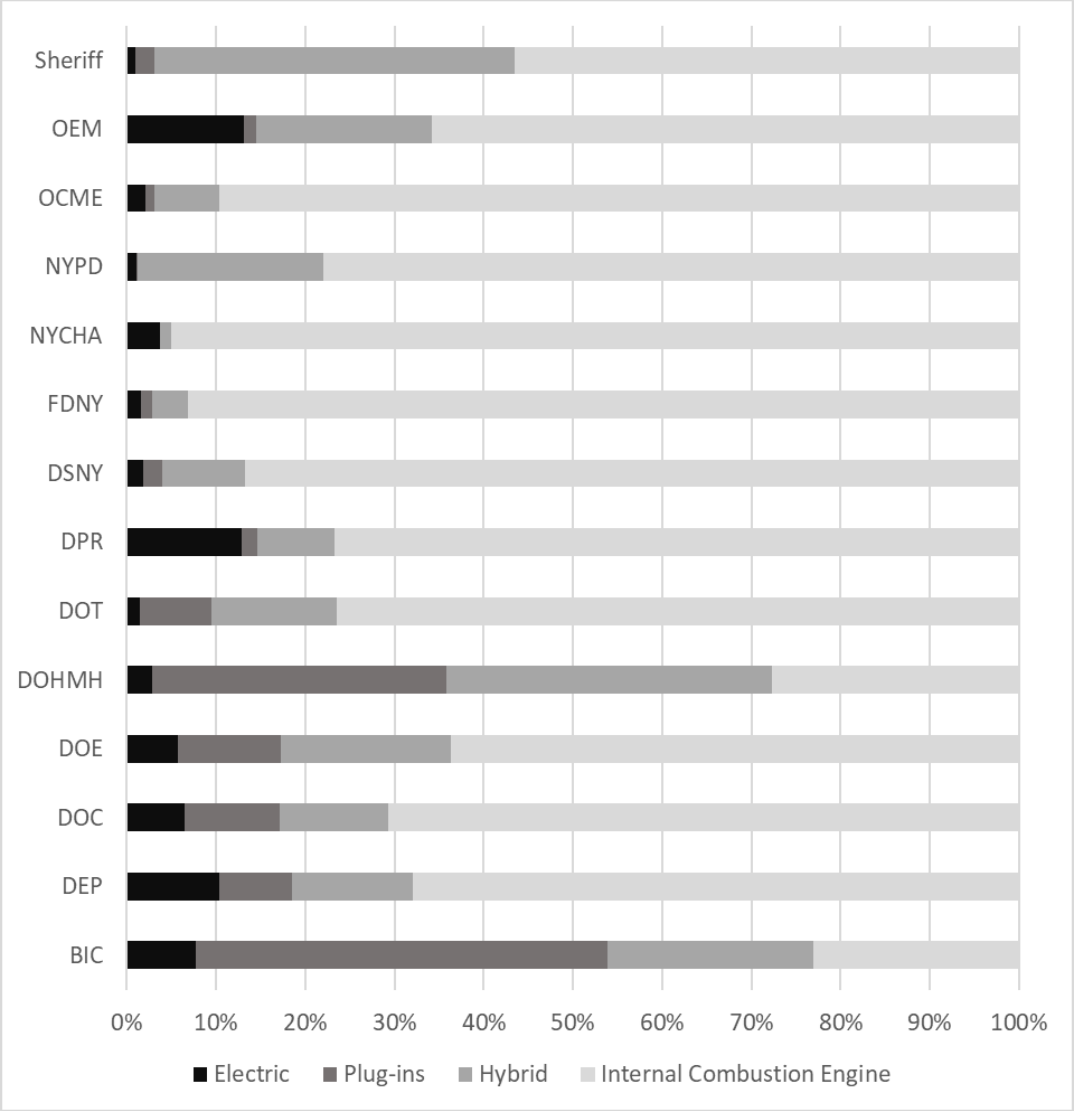

Figure 3. Fleet Fuel Composition by Agency

2.2 Themes Identified across Agencies

The following sections document the major themes that the agencies reported in the discussions. Highlights include the following:

Agencies believe there is an overall shortage of charging stations across the city, and there are limited physical spaces and parking lots in which to install them. Installing chargers at leased buildings is a challenge with building owners. While many vehicles can use Level 2 chargers, some vehicles require higher-voltage direct current fast chargers (DCFC).[6] Installing an adequate number of chargers may

[6] DCFC typically provide a power level of 50-350 kilowatts per port. Level 2 chargers typically provide about 7.7 kW of power.

strain a building's electrical infrastructure; many buildings in New York City are old and require grid updates. Additionally, there may be challenges charging commuter vehicles overnight. Some agencies have more charging infrastructure in place than others, so inter-agency collaboration on this issue is necessary. DCAS has announced a major investment in additional charging, up to 1776 fast chargers by 2030.

First responders and emergency services seek charge times under 30 minutes. Vehicles used for emergency response could deploy at any time 24 hours a day, 7 days a week and need to be available at a moment's notice. They also have special charging needs because they could be parked almost anywhere at the time of deployment and they may need to unplug rapidly or automatically when headed to emergency operations. EVs with DCFC capability and/or long ranges are desirable. These agencies may also require quick portable charging for emergency activations. DCAS is in fact responding to these needs with plans to bid 125 to 250 KW chargers. Current fast chargers are 50KW.

Some agencies with HDVs report hesitance to test new BEVs and prefer HEV or EV retrofits. Heavy duty vehicles (HDVs) include vocational trucks, fire trucks, school buses, etc. Concerns surfaced about reliability, operational capabilities, market availability, and the lack of necessary DCFC chargers. Agencies reported that upfront costs for new BEVs are high, especially for trucks, and retrofits may be less expensive and more cost-effective. (Since these discussions, DCAS has since announced a repower initiative for trucks.) These agencies report that internal combustion engines (ICE) paired with fuel efficiency technologies, hybrid capability, or biodiesels may be easier than testing a BEV. However, agencies report that buses and certain other HDV classes have been some of the earliest adopters of EV technology.

Some agencies idle their vehicles to power equipment. This equipment may include emergency lighting, refrigeration, tree trimming, or compressor equipment. These vehicles would benefit from battery auxiliary power units (APUs) so that the engine does not have to run while powering equipment. The City has made significant strides on FDNY ambulances, reducing idling with retrofitted and original equipment manufacturer systems and will review other opportunities to deploy APUs during the transition to an all-electric fleet.[7] The ambulances also have plug in capacity. DCAS and FDNY are working to develop effective ways to plug these units in without operational disruption.

Many agencies transport passengers in vans or buses. With many EV models in that segment coming in the next few years and previous implementation with aftermarket retrofits such as from XL Hybrid, these have a high potential for electrification, though agencies reported supply issues.

[7] In addition to greenhouse emissions, idle reduction also benefits communities through local air quality improvements.

Fuel efficiency technology is concentrated among agencies with specialized HDVs. These technologies include biofuels including biodiesel and renewable diesel, tire technologies, and idle reduction technologies. Fuel efficiency add-ons are often more feasible than complete electrification for HDVs. DCAS is pursuing a long-term renewable diesel contract to switch out diesel fuel for trucks and off-road equipment until electric options emerge.

PHEVs are popular among agencies that have started electrifying their LD fleet. The Toyota Prius Prime, in particular, has seen success in daily use.[8] Ensuring that PHEVs are reliably plugged in and charged has been a challenge.

Some agencies need to accommodate back seat partitions for transport or storage space to transport specialized equipment and cannot downsize all their vehicles. Others, like the Sheriff's Office, are open to downsizing but are worried about space and prisoner transport needs. In the interest of fuel efficiency and accelerated electrification, LD SUVs can be downsized to sedans, crossovers, and minivans, where possible.

Many agencies do not yet use telematics for fuel efficiency purposes. Many vehicles are already equipped with telematics. DCAS tracks over 27,000 vehicles through its Fleet Office of Real Time Tracking. Telematics has been used to measure characteristics like speed, location, and idling time. However, many agencies report not using it fully or not seeing what other data they can track. Using telematics to avoid surprise empty batteries would be beneficial for agencies and would highlight the benefits of telematics for clean fleets.[9]

Table 3 summarizes the key takeaways from the interviews and their applicability to specific agencies.

[8] A caveat with PHEVs is that they must be plugged in to be effective in meeting the NYC electrification goals.
[9] Telematics could also provide data to inform the siting of electric vehicle supply equipment (EVSE).

Table 3. Key Findings by Agency

FINDINGS:	BIC	DEP	DOC	DOE	DOHMH	DOT	DPR	DSNY	FDNY	NYCHA	NYPD	OCME	OEM	Sheriff
Charging station shortage reported	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reported need for fast charging times				✓	✓			✓			✓			
Preference for hybrids or retrofits			✓	✓		✓		✓	✓					
Reported need for 24/7 vehicle availability		✓		✓	✓			✓	✓		✓			
Idle vehicles to power equipment		✓		✓		✓						✓		✓
Potential for bus or passenger van electrification			✓	✓							✓	✓		✓
Fuel efficiency technology concentrated among HDVs			✓			✓	✓	✓	✓			✓		
Problems reported with CNG vehicles						✓	✓	✓						
Hybrids popular in LD fleet					✓	✓								
Downsizing reported not possible due to storage needs or specialized equipment				✓			✓					✓		✓
Telematics enabled on vehicles but underutilized		✓	✓	✓	✓	✓	✓		✓				✓	

3 Clean Fleet Technology Readiness

3.1 Vehicle Categorization Methodology

The city's fleet is comprised of over 29,500 vehicles, ranging from small cars to specialized HDVs and nearly everything in between. While New York City internally assigns vehicles to weight classes based on Local Law 38, this report refers to the weight classes used by the Federal Highway Administration. The tables below show how they differ.

Table 4. Federal Highway Administration Vehicle Weight Classification

GVWR (lbs.)	Vehicle Class	GVWR Category
<6,000	Class 1	LD
6,001 - 10,000	Class 2	
10,001 - 14,000	Class 3	MD
14,001 - 16,000	Class 4	
16,001 - 19,500	Class 5	
19,501 - 26,000	Class 6	
26,001 – 33,000	Class 7	HD
>33,000	Class 8	

Table 5. Local Law 38 Vehicle Weight Classification

GVWR (lbs.)	Vehicle Class
< 8,500	LD
8,500 – 14,000	MD
> 14,000	HD

Volpe's analysis grouped vehicles into categories based on weight class, function, and other characteristics. For example, the category "cars" encompasses many Class 1 vehicles (up to 6,000 pounds (lbs.) Gross Vehicle Weight Rating (GVWR)), including small crossovers, traditional four-door sedans, and some "crossover" style vehicles.

Sport utility vehicles (SUVs) have their own category to distinguish between them and crossover vehicles. SUVs in this instance are defined as "body-on-frame" vehicles, whose construction uses a main "ladder" frame, solid rear axle, and other design elements like those employed on pickup truck platforms. These designs offer greater payload and towing capabilities compared to unibody vehicles (crossovers) that do not have body-on-frame construction. For example, a Ford Edge is not considered an SUV for this categorization, whereas a Ford Explorer or Expedition would be considered an SUV.

Some SUVs, passenger vans, cargo vans, and pickup trucks (including cutaway, Figure 4, and stripped chassis, Figure 5, "work" applications[10]) span LD and MD segments, defined by the vehicle's weight rating.

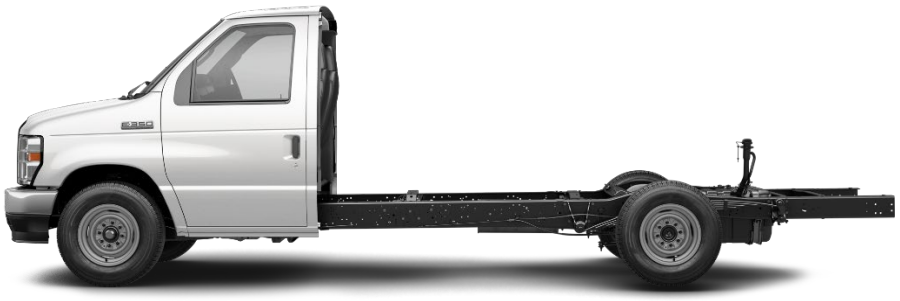

Figure 4: Ford E350 Cutaway (Source: Fordville.net)

Figure 5: Ford E350 Stripped Chassis (Source: alpackerford.net)

Light-duty (LD) vehicles are functionally separated by weight class and include all Class 1, 2a, and 2b vehicles, ranging up to 10,000 lbs. GVWR.[11] Class 1 vehicles include sedans, hatchbacks, minivans, crossovers, and some small pickup trucks. Minivans have a dedicated category within Class 1 vehicles, whereas passenger or cargo vans (which are usually larger in size and designed to handle bigger payloads) are Class 2a or 2b vehicles. Pickup trucks, vans, and SUVs are found in Class 2a (1500/150-series platforms), 2b (2500/250-series platforms), and Class 3 (3500/350-series platforms). Given the nature of 2b and 3 vehicles, which are often used for commercial purposes and offered in truck, van, cutaway and stripped chassis configurations, 2b/3 vehicles are often grouped together. These vehicles are often the last to receive attention in government programs and policies because they fall between LD passenger vehicles and MD and HD commercial vehicles. Approximately 16 million 2b/3 vehicles are registered nationally, 13 million of which are class 2B vehicles.

[10] A "work truck" or "work van" denotes a model range offering "cutaway" or "stripped chassis" platforms that underpin specialty bodied applications for passenger transport, emergency response uses, or vocational applications. A cutaway platform retains the forward cab portion of the vehicle, while a stripped chassis is a bare chassis with driveline components, lacking any body elements.

[11] https://afdc.energy.gov/data/10381

Medium-duty (MD) vehicles are generally commercial use (often requiring a commercial driver's license to operate) and encompass Class 3 thru Class 6 with GVWRs ranging from 10,001 lbs. to 26,000 lbs. These vehicles feature a wide variety of body types and functionality, like 2b/3 trucks, and include cutaway and stripped chassis options. MD variants include 4500/450, 5500/550, or 6500/650 models from major manufacturers like GM, Ford and Stellantis (Ram). Commercial truck manufacturers such as Peterbilt, International, Mack, etc. offer Class 5 and 6 trucks as well.

Vehicles built upon available truck chassis (cutaway or stripped) include shuttle buses, school buses, utility/bucket trucks, fire trucks, ambulances, delivery trucks or box vans, and other vocation-oriented vehicles. Historically, using mass-produced truck chassis onto which specialty and vocational bodies are fitted has helped to provide lower-cost solutions compared to dedicated chassis applications.

To date, several of the original equipment chassis from major manufacturers (e.g., Peterbilt, Kenworth, International and BYD) have MD products available with electric drivetrains.[12] Final constructors of specialty vehicle types built off these standard chassis also offer electrified or hybridized vehicles for sale as new vehicles that have been converted and offer new vehicle warranties (often a combination of the manufacturer's warranty and constructor's warranty on conversion systems).

Heavy-duty (HD) vehicles include Class 7 and 8 platforms, with GVWRs ranging from 26,000 lbs. to over 33,000 lbs. Select applications for HD EVs include low-floor transit buses, school buses, fire trucks, dump trucks, sanitation/garbage trucks, and other large vehicles with predictable (or scheduled) daily routes, centralized parking to facilitate charging, and tend to operate at lower speeds over shorter distances.

For each vehicle category, Volpe researchers assigned a Tier rating based on public information on market availability and using the below definitions. Market availability as defined here is separate from the City's specific procurement requirements and timetables. Subsequent developments impacting fleet supply chains or manufacturers plans could impact these timetables.

> **Tier 1 –** Market-available "in-kind" vehicle options exist for immediate ordering and implementation within 3 years. Availability presumes production can satisfy demand. Included in Tier 1 (and indicated in italics in the table below) are new, specialty vehicles that utilize the chassis from a major manufacture and third-party battery-electric drivetrains.
>
> **Tier 2** – Includes vehicle types in market segments with solutions that have been announced for future model year availability starting in 2025, and those able to be deployed within 3-5 years. Tier 2 includes vehicles that may be available sooner; however, they are not expected to be produced in significant numbers during early model runs.[13]

[12] https://globaldrivetozero.org/tools/zero-emission-technology-inventory/

[13] A common strategy for both new technology vehicles and new manufacturers of EVs has been to launch premium, upscale versions of a new platform to accelerate interest and leverage higher profit margins on premium

Tier 3 – No available vehicle solutions on the market, with none known to be planned by major original equipment manufacturers within 5 years. Gaps in availability within Tier 3 vehicles may be addressed by new market entrants; however, some gaps are driven by technical shortcomings or the inability to meet functional performance requirements. For these reasons DSNY collection trucks that are used for plowing have been designated as Tier 3 vehicles.

Table 6 summarizes the Tier designations for the most common vehicle categories, and the narrative that follows provides supporting information.[14] The appendix provides a full listing of all vehicle types by tier. The Tier designation is based on the availability of each vehicle type as an all-electric new purchase, regardless of whether the product is from an established major manufacturer or a new market entrant, and regardless of whether the product is built entirely in-house by that company or converted from a standard chassis that was built by another company, i.e., a "new upfit," as long as they offer new vehicle warranties. In the latter case, the warranty is often a combination of the manufacturer's warranty and the constructor's warranty on conversion systems. Volpe's analysis distinguishes these "new upfits," which appear in the tiers table in *italics*, from "aftermarket retrofits," which do not appear in the tiers table. While "aftermarket retrofits" do not appear in the tiers table, they do appear in the narrative discussions for the vehicle categories that follow. The only company highlighted in this regard is XL Fleet, which provides hybrid and plug-in hybrid "aftermarket retrofits." DCAS is in fact investing in XL hybrids for class 2 units now. This analysis did not identify any companies that market all-electric "aftermarket retrofit" solutions. DCAS is separately exploring options for retrofits to electric, or "repowers" of older trucks.

equipment while waiting to launch more affordable versions (more closely aligned with typical fleet vehicles). Pre-orders and other methods of procurement that City rules may not allow could affect availability.

[14] See Appendix A for tier designations by DCAS standard type, which are used to categorize vehicles in the DCAS fleet roster.

3.2 Tiered Technology Availability Summary

Table 6: Tiered Technology Availability for the Most Common Vehicle Categories with Examples

Tier	Vehicle Categories	Selected Example Vehicles (*Retrofit Solutions in Italics*)
Tier 1	LD Class 1 and 2a: cars, pickup trucks, passenger, and cargo vans.	**Sedans**: Tesla Model 3 (Police version available) MB EQS; **Hatchbacks**: Chevy Bolt (Police version available), BMW i3 (Police version available), VW ID.4, Hyundai Kona, Nissan Leaf, MINI Cooper SE, Polestar 2; Jaguar I-Pace; Porsche Taycan; **Crossovers**: Ford Mach E (Police version available), Audi e-Tron, Hyundai Ioniq, Kia Niro, Tesla Model Y, Tesla Model X **Pickup trucks**: Rivian R1T, Ford F150 Lightning, Silverado EV, Tesla Cybertruck **Passenger / cargo vans**: Ford Transit Connect, *Lightning eMotors Ford Transit passenger van*
	LD Class 2b: passenger and cargo vans.	**Passenger / cargo vans** (all w/ dedicated chassis): Ford e-Transit, *Lightning eMotors Transit Passenger Van*, Brightdrop EV600
	MD Class 4-6: common work truck platforms (F450/4500, etc.) that underpin different bodies including shuttle & school buses, step vans, delivery vans, box trucks, and ambulances.	**Shuttle buses, school buses, step vans, delivery vans, box trucks**: *New EV upfit of popular MD truck chassis: Collins Bus Corporation (Type A school bus / F450) Lightning eMotors (multiple chassis and body types), Motiv Power Systems (multiple chassis and body types), Phoenix Motorcars (Ford F450/F59 chassis)*; Lion Electric low-floor shuttle bus (Lion M – dedicated chassis) Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6 **Type II and III ambulance**: Demers eFX (dedicated chassis)
	HD Class 7-8: transit and school buses, fire apparatus, and collection trucks.	**School buses:** Blue Bird (Type C&D), BYD, IC Bus (Type C), Lion, Thomas Built (Type C w/ Proterra system), **Transit buses**: BYD, ENC (El Dorado National), Gillig, New Flyer, NOVA, MCI, Proterra **Collection trucks**: Mack LR Electric, BYD 8R, Lion8
Tier 2	LD Class 1 and 2a: minivans, SUVs (Consumer & Police).	**Minivans**: Mercedes Bens EQV, Chrysler Pacifica EV, Canoo **SUVs**: Rivian R1S, Ford Explorer, Chevy Tahoe
	LD Class 2b/3: SUVs, cargo vans and pickup trucks	**SUVs**: Ford Excursion EV **HD Pickup Trucks**: Ford Lightning HD, Chevy Silverado HD **Cargo / passenger vans**: Bollinger Deliver-E, Mercedes Benz e-Sprinter *Note: NYPD vans and buses are currently Tier 3
	MD Class 4-6: work trucks (and subsequent body types incl. shuttle, vocational, fire, ambulance (type 1), etc.)	**Work trucks and Type I Ambulance**: *Dedicated chassis, not upfits.* Zeus Electric Chassis; Bollinger Work Truck Chassis

Tier 3	HD Class 7-8: collection trucks for plowing	Not currently available, requires enhanced energy management and/or increased density to accommodate extended, continuous use in cold temperatures. DCAS to test 7 BEV garbage trucks for plowing function.
	HD Class 8: fire ladder trucks	Not currently available; Rosenbauer announcement for 2023 in European market **Fire pumper apparatus**: Models announced but unclear whether they match NYC requirements (Pierce Volterra, E-ONE Vector, Rosenbauer)

3.3 Tier I

There are numerous EV options on the market, and even more have been announced through model year 2024. Light-duty vehicles (LDVs), and particularly Class 1 vehicles, are broadly available from major manufacturers across body styles including sedans and crossovers. Included among these are smaller pickup trucks, passenger vans, and cargo vans. While law enforcement comprises a vast operational arena, the market is starting to support various aspects of this including enforcement and emergency response units. Medium-duty (MD) options include both original equipment manufacturer and EV "upfit" conversions[15] of popular commercial work-truck chassis, and HD options including some collection trucks, nearly all school and transit buses, and select emergency response vehicles such as fire trucks and some types of ambulances.

Many larger EV solutions target specific duty cycles such as shorter or fixed trips and return to base with central parking and charging. Some dedicated chassis are available (ambulance, fire, transit bus, etc.) along with upfitted solutions that typically retain manufacturer warranties and include matching warranties for the technology solution employed.

Examples of upfitters that provide electrified new vehicle EV solutions for common work-truck platforms include:

- **1FPG (First Priority Emergency Vehicles, Inc.)** offers electrified emergency response vehicles for fire and police applications on Ford Van and Truck Chassis (Class 2-6).[16]
- **Lightning eMotors** produces electrified powertrains for Ford Transit 350HD, Ford E-450, F-59 and F-550 as well as Chevy 6500XD truck platforms.[17]
- **Motiv Power Systems** provides electrified powertrains for Ford F450, F-59 and F-550 chassis.[18]

[15] EV upfit solutions utilize an available chassis from a major manufacturer, intended to house internal-combustion engines and traditional fuel systems. Upfitters obtain a new chassis from the manufacturer, remove the original engine and fuel system, replacing with a new electric drive system (including motors, batteries, and associated hardware, wiring, etc.).

[16] https://www.1fpg.com/electrified

[17] https://lightningemotors.com/electric-commercial-vehicles/

[18] https://www.motivps.com/epic/

- **Phoenix Motorcars** produces electrified powertrains for the Ford E-450 chassis including shuttle bus, vocational truck, and school bus bodies.[19]

Recent EV manufacturer start-ups are beginning to, or plan to, offer ground-up EV designs that compete with some of these upfit solutions, where the drivetrain, chassis, and vocational body are optimized for electrification and the functions desired. These offerings include specialty-bodied vehicles like ambulances and fire equipment as well as new all-electric work truck platforms designed to compete directly with the base platforms like F450-F650 and larger trucks that underpin upfitted solutions. See Tier 2 section below for more detail.

Also available are aftermarket retrofit "bolt-on" hybrid or plug-in hybrid systems that augment original, internal combustion drivetrains with an aim of improving fuel economy. These systems are retrofitted to purchased vehicles after delivery from the manufacturer.[20]

3.3.1 Cars (Class 1 Sedans, and Crossovers)

Light-duty vehicles (LDVs) are designated as Tier 1 for their ready availability and wide range of options. Note that, per the categorization methodology described in the introduction to this section, hatchbacks, sedans, and crossovers are all part of this category. Many BEV models are currently sold in the United States, with several more slated for the next two years. The relatively high number of BEV offerings from multiple manufacturers has consequently led to diversity in available vehicle characteristics such as body style, performance, features, range, and price point.

How long these BEV models have been in production varies. Some, like the Nissan Leaf and Chevrolet Bolt, have been produced and sold for several years.[21] Many other BEV models have been announced recently or are just now starting to be produced and sold, e.g., the Volkswagen ID.4 and Chevrolet Bolt EUV. In the longer term, while several upcoming BEV models are announced for 2023 and beyond, few are sedans or hatchbacks. This shift reflects the broader industry trend of a reduction in the number of small cars offered.[22] Manufacturers that are introducing new electrified models favor crossovers and SUVs. This trend is also true in police vehicles, where most sedan models have been removed from the market. This trend toward larger units, even when electric, can impact environmental and safety benefits. Even where all-electric options exist for larger vehicle types, downsizing to vehicle platforms that still perform the mission can provide benefits in terms of greater operational efficiency, reduced unit cost, reduced lifecycle environmental impacts, and improved crash safety for vulnerable road users.

[19] https://www.phoenixmotorcars.com/products/
[20] XL Fleet offers hybrid and plug-in hybrid solutions for Class 2-6 vehicles from Ford, GM, Isuzu and Stellantis (formerly Fiat Chrysler Automobiles), see: https://xlfleet.com/vehicles/.
[21] The Leaf and the Bolt have been sold in the U.S. since 2010 and 2016, respectively. They are already present in the NYC fleet roster, representing 605 vehicles in total. [NYC fleet roster as of November 19, 2021]
[22] https://www.epa.gov/automotive-trends/highlights-automotive-trends-report

In addition to fully electrified models, there are also many existing vehicles on the market with hybrid and plug-in hybrid powertrains, some of which are versions of popular ICE vehicles. The Toyota Corolla, Hyundai Sonata, and Honda Accord hybrids are prime examples of hybridized nameplates with ICE counterparts currently represented in the NYC fleet.

3.3.1.1 Police Cars (Class 1; Sedans, Hatchbacks, Crossovers)

There is currently a burgeoning but limited market for all-electric police cars, as these vehicles have performance needs that are not necessarily met by currently available BEVs. To date, only a handful of police departments across the U.S. own BEVs.[23] DCAS purchased 184 Ford Mustang Mach-E crossover vehicles "for law enforcement and emergency response use."[24] The 2022 Mach-E has passed rigorous performance testing by the Michigan State Police; it is the first BEV to do so.[25] The NYPD has also tested a single Tesla unit for policing use. A Chevy Blazer electric police unit has been announced for 2024.[26]

3.3.2 Pickup Trucks (Class 2a)

Light-duty (LD) pickups span different weight classes, each offering ever increasing GVWR and subsequently, payload and towing capabilities. Popular models include domestic 150 and 1500-series trucks, with GVWRs up to 8,500 lbs. Several models are set to be produced in the coming two years. Some are from large-volume manufacturers, such as the Ford F-150 Lightning and Hummer EV Pickup, while others will be offered by startups such as Rivian, Canoo, and Bollinger. DCAS is currently implementing a contract for the Ford Lightning. Tesla also has plans to release a pickup, branded as the Cybertruck. Offerings from well-established manufacturers may better serve NYC's needs because these offerings are more likely to be produced in sufficiently high volumes and to have better support networks as new products. Some of the most popular ICE pickups from the have electrified counterparts coming in the next few years, including the Ram 1500, GMC Sierra, Chevrolet Silverado, etc. Pickups in NYC Fleet operations perform many functions including plowing and off-road work. Electric vehicles will need to be able to support these functions to be ready for adoption.

An extremely limited selection of hybrid technology exists within the pickup segment. Ford offers a hybrid engine option on the 2021 F-150 as well as the new 2022 Maverick (a compact Class 1 pickup closer in size to the Ford Ranger, which may provide an opportunity to downsize). XL Fleet, a Boston-based fleet electrification company, offers plug-in hybrid aftermarket retrofits on the F-150.[27] The

[23] https://www.police1.com/patrol-cars/articles/trending-topic-electric-vehicles-for-public-safety-xEqLDCKwUx8x7mSO/
[24] https://www1.nyc.gov/site/dcas/news/21-020/nyc-taking-another-step-towards-achieving-all-electric-municipal-fleet
[25] https://www.michigan.gov/documents/msp/MY2022PoliceVehicleEvaluationTestBook_742651_7.pdf
[26] https://www.cnet.com/roadshow/news/chevy-blazer-ev-police-pursuit-vehicle/
[27] https://xlfleet.com/assets/Uploads/XL-XLP-Ford-F150-FLY.pdf

capacity to tow equipment, plow snow, and support work functions such as water tanks, salt spreaders, and automatic lift-gates, will be critical to successful adoptions of electric pickup trucks.

3.3.3 Passenger and Cargo Vans (Class 1-2b)

Multiple electric van models have been announced or produced by both major manufacturers and new market entrants. Popular examples of ICE LD cargo vans include the Ford Transit Connect and Ford Transit, which together represent 400 vehicles in the City's fleet.[28] DCAS has submitted orders for the E-Transit, which is available in three body lengths and three roof heights; production began in early 2022.[29] Brightdrop, a newly created brand under GM, began production of its EV600 cargo van in fall 2021. A smaller counterpart of the EV600, called the EV410, will follow around 2024. Mercedes-Benz also plans to begin producing an electric version of its Sprinter van, called the eSprinter, in late 2023.[30] Electric van units may have lower payload capacity than comparable gas/diesel units, and this difference should be assessed for operational impact.

3.3.4 Collection Trucks

This section addresses collection trucks that are only used for collecting and transporting refuse. In New York City, collection trucks are also used for snow plowing operations, which are performed mostly by the Department of Sanitation. For a discussion of collection trucks that also perform plowing, refer to the Tier 3 section below. Collection trucks are divided into sub-categories based on the vehicle's method of collecting waste: front loaders, rear loaders, and side loaders.[31] The majority of waste collection trucks in the NYC fleet are rear loaders (about 1,700 vehicles); there are also about 600 side loaders and 100 front loaders.

Side and rear loader electric garbage trucks have been on the market for many years, but front-loader types have not (which have been classified as Tier 2). If the existing 100 front loader garbage trucks in the NYC fleet cannot be replaced with side or rear loader models, then a separate sub-category at a different tier level other than Tier 1 may be warranted. Motiv Power systems began deliveries of its rear-loader Electric Refuse Vehicle (ERV) in 2014, though it is not currently offered,[32] and since 2020 SEA offers repowers of Autocar Xpeditor and Freightliner EconicSD refuse trucks.[33] BYD began deliveries of its automated side-loader 8R Refuse Truck in 2017 and its rear-loader 6R model in 2021.[34] Two models

[28] NYC Fleet Roster
[29] https://tcrn.ch/3r00qu7
[30] https://www.cnet.com/roadshow/news/mercedes-esprinter-south-carolina-production/
[31] https://en.wikipedia.org/wiki/Garbage_truck
[32] https://www.motivps.com/news/first-all-electric-garbage-truck-in-north-america-developed-by-motiv-power-systems-hits-the-road-in-chicago/
[33] https://globaldrivetozero.org/tools/zero-emission-technology-inventory/
[34] https://cleantechnica.com/2017/11/21/byd-delivers-1st-electric-automated-side-loader-garbage-truck-city-palo-alto-greenwaste/; https://www.truckinginfo.com/10153141/city-of-hyattsville-operates-first-fully-electric-trash-truck

were introduced as recently as 2020: Lion Electric's side-loader Lion8 Refuse variant[35] and Mack's rear-loader LR Electric. NYC recently ordered 7 Mack LR Electric Trucks in summer 2021, after deploying a demonstration model of the vehicle the previous year.[36]

3.3.5 School and Transit Buses

All New York City school bus services are contracted out to private companies. The City does not own or procure school buses in general, although it has procured an initial three electric school buses that are City-owned. However, there is a separate NYC Local Law for school buses in New York City to become electric by 2035, and the Department of Education Office of Pupil Transportation (OPT) and the bus contractors are partnering with the City to achieve this goal.[37] School buses are categorized into four subtypes based on size and architecture, referred to as Types A through D. Type A are small buses constructed with a cutaway front section with seating capacities up to 10 passengers. Type B utilize a stripped chassis construction and carry more than 10 passengers. Type C, the most common school bus type, features a front engine with a hood and fenders; they vary in length but can seat anywhere from 54 to 78. Type D, referred to as the "transit bus" style, are the largest school buses and are offered in front-, mid-, or rear-engine configurations, typically seating between 72 and 90 passengers.

Electric school buses have been available for several years, both from well-established manufacturers (Thomas Built Buses, Blue Bird, IC Bus) and startups (Lion Electric). These vehicles are offered in a variety of lengths, ranges, and seating capacities, although one challenge is that New York State bridge and tunnel regulations may preclude the use of some school bus models that are too wide to comply. NYC-wide reliability and charging plans for these units would help support their large-scale adoption.

DOE and the school bus companies will face many of the same operational issues as the City fleet in implementing this ambitious transition. These include:

- Matching electric vehicle supply equipment (EVSE) charging capacities to school routes and parking locations, including the addressing potential need to re-charge or top-off midday.
- Determining whether Level 2 or DCFC charging is best for the long-term condition of the EV busses.
- Establishing the reliability of various models of electric school busses for the different bus types. DOE plans to be careful to avoid disruption of transport for school children as this transition and the assessment of technologies unfolds.
- Assessing the maintenance and repair needs for the busses and whether predicted maintenance savings are achieved.
- Developing vehicle to grid capacity at the school bus and charging level to support peak load grid management opportunities.

[35] https://pages.thelionelectric.com/all-electric-lion8-refuse-truck-lion-electric/
[36] https://www.macktrucks.com/mack-news/2020/first-mack-lr-electric-model-begins-service-with-new-york-city-department-of-sanitation/
[37] https://www1.nyc.gov/office-of-the-mayor/news/296-21/recovery-all-us-mayor-de-blasio-commits-100-electric-school-bus-fleet-2035

- Handling some of the unique challenges of parking of school buses, which are often done in small parking lots, on the curb, or at school bus drivers' homes.

Working with DCAS, Volpe will explore the school bus EV transition in more depth in the next update to the CFTP including further interviews with the DOE Office of Pupil Transportation, select school bus companies, and the non-profit NYC School Bus Umbrella Corporation (NYCSBUS).

3.3.6 Ambulances (Type II and III)

Ambulances in North America are classified into Types I through IV, which are defined based on the chassis. Most of the 700+ ambulances in the NYC fleet are Type I, which consists of a heavy truck chassis-cab with a custom "box", or rear compartment.[38] There are also several Type III ambulances that are based on a van chassis-cab. Like Type I ambulances, they have a custom rear compartment and many of the same use cases.[39]

Unlike Type II and III, Type I ambulances are designated as Tier 2 for market availability. See "Ambulances (Type I)" section in the Tier 2 section below. The FDNY and DCAS have implemented a wide-scale program of APUs for its Type 1 ambulances which enables these units to operate as hybrid unit and limit fuel use and maintenance costs tied to idling. These units are technically PHEVs, as they include a plug-in capacity. The City is still working to develop an effective way to implement plug in options that will not impact ambulance response operations.

3.3.6.1 Type II and III

Electric ambulances are just now starting to become market available. The Demers eFX Ambulance, is a Type III ambulance, scheduled to be commercialized in late 2022.[40] It is the only announced Type III all-electric ambulance that researchers found as of the writing of this report.

Lightning eMotors and REV Group are co-developing an electric ambulance, scheduled to be produced April 2022, based on the Ford Transit cargo van. [41,42] However, these vehicles are based on commercial HD vans and would fall under Type II. Type II ambulances have different use cases than Types I and III, only supporting basic life support features, as opposed to advanced life support features that require additional equipment and weight. The City is considering investing in Type II ambulances for specific emergency response functions.

[38] https://en.wikipedia.org/wiki/Ambulance
[39] https://www.braunambulances.com/custom-ambulances/ambulance-types/
[40] https://ir.thelionelectric.com/English/news/news-details/2021/Demers-Ambulances-and-Lion-Electric-Launch-All-electric-Purpose-Built-Ambulance/default.aspx
[41] https://lightningemotors.com/lightning-emotors-and-rev-group-subsidiary-to-produce-electric-ambulances/
[42] https://www.autoevolution.com/news/battery-electric-ambulances-to-operate-on-the-roads-of-california-starting-next-year-176578.html

3.3.7 Emergency Response – Specialty Use

Aside from school buses, transit buses, fire apparatus, and some ambulances, the city also relies on mobile command centers to handle emergency response coordination in the field. This specialty application has unique power requirements, and no all-electric original equipment manufacturer solutions appear to be currently available. However, First Priority Group offers EV conversions for mobile command applications.[43] This is an area DCAS may wish to explore as it rolls out a repower initiative.

3.4 Tier 2

Tier 2 covers vehicle types that are anticipated to be in the market within 2-5 years, such as larger LD SUVs, pickup trucks, and minivans.

3.4.1 Traditional-Use SUVs

Electric SUVs are very limited in the market. Rivian offers the R1 SUV. A few are coming in the next five years. As noted above, new BEV models tend to be crossovers. A Ford Explorer EV and GMC Hummer SUV EV are planned for production around 2024. The Ford Explorer EV was recently delayed by Ford in favor of scaling up production of the Mach-E, its electric crossover.[44] If electric crossover sales from other manufacturers are as successful as the Mach-E, it is possible that they may adopt similar strategies and consequently delay or disregard the development of full-size SUVs. Additionally, it is more of a challenge to design full-size SUVs because they are larger and heavier, demanding larger batteries to achieve the same range as smaller vehicles, and SUV manufacturers may wait for advancements in EV battery technology. The Ford Explorer and Toyota Highlander are also offered as hybrids.

3.4.2 Police SUVs

There are no electric SUVs for police enforcement and response use currently available. Chevy has announced an EV blazer for police use in 2024. With the release of the Explorer EV slated for 2024, it is possible that Ford will release a police version. However, the Ford Interceptor Hybrid (a modified version of the Explorer) is currently available. The NYPD has been adopting this hybrid unit as it assesses all-electric options. Other hybrid SUV models might also be used in police applications; see the section on traditional-use SUVs.

[43] https://www.1fpg.com/electrified
[44] https://www.cnet.com/roadshow/news/ford-explorer-lincoln-aviator-ev-mustang-mach-e-delay/

3.4.3 Ambulances (Type I)

Ambulances in North America are classified into Types I through IV, which are defined by the chassis on which the vehicle is based. Most of the 700+ ambulances in the NYC fleet are Type I, which consists of a heavy truck chassis-cab with a custom "box", or rear compartment.[45] Currently, no BEV Type I ambulances are available on the market. Type I ambulances will likely become market available with the availability of Class 4 EV work trucks. The City YC also has some Type III ambulances that are based on a van chassis-cab; like Type I ambulances, they have a custom rear compartment and many of the same use cases.[46] Unlike Type I, Type III ambulances are designated as Tier 1 for market availability. See "Ambulances (Type II and III)" section in the Tier 1 section above for a discussion of the availability of these types.

3.4.4 Minivans

Popular minivan models in the U.S. today include the Chrysler Pacifica, Honda Odyssey, and Toyota Sienna. No major manufacturer has announced a BEV minivan model that is directly comparable to these models. The two primary upcoming EV minivans, the Volkswagen ID. Buzz and the Canoo Lifestyle Vehicle, mimic the form factor of the classic Volkswagen Bus camper van. However, both vehicles reportedly offer packages that include seating for up to seven people.[47, 48] In addition, the Chrysler Pacifica is also offered as a PHEV, while the Toyota Sienna is now offered only as an HEV. NYC has introduced Pacifica PHEV units into its fleet.

3.4.5 Light-Duty Pickup Trucks (Class 2b-3)

Popular commercial work truck platforms in this LD pickup truck category include 250 and 2500 series trucks with GVWRs up to 10,000 lbs. Class 2b trucks and above are often available as "stripped chassis" where instead of an empty truck bed behind the truck cab, the bare chassis offers a foundation for mounting a plethora of bodies, attachments, or other functional elements, including mechanical or vocational bodies, dump bodies, and other work and construction configurations.

Recently, GM announced that it intends to electrify all its pickup models, including the "heavy duty" (Class 3) models, by 2035.[49] However, Ford currently has no public plans to electrify its vehicles in that segment.[50] XL Fleet offers hybrid and plug-in hybrid aftermarket retrofits for many popular Class 2-6 models from Ford, GM, Isuzu, and Stellantis.

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[45] https://en.wikipedia.org/wiki/Ambulance
[46] https://www.braunambulances.com/custom-ambulances/ambulance-types/
[47] https://www.caranddriver.com/news/a38160384/volkswagen-id-buzz-preview/
[48] Canoo Lifestyle Vehicle Premium trim, https://www.canoo.com/canoo/
[49] https://www.caranddriver.com/news/a38696855/general-motors-electric-heavy-duty-trucks/
[50] https://www.motor1.com/news/550700/ford-no-electric-super-duty/

3.4.6 Medium-duty Pickup Trucks (Class 4-6)

Currently, no announced products from major original equipment manufacturers exist in this segment. XL Fleet offers hybrid and plug-in hybrid aftermarket retrofits for many popular Class 2-6 models from Ford, GM, Isuzu, and Stellantis.

New or recently established companies are beginning to offer holistic solutions with dedicated work truck chassis and electrified drivetrains, such as Zeus Electric Chassis,[51] whose platforms are designed to utilize common original equipment manufacturer patterns (bolt locations, chassis design and mount locations, etc.) like Ford and GM work trucks for ease of integration with existing bodies and vocational elements

Zeus Electric Chassis, a startup EV manufacturer from Minnesota, provides a "true class 4-6 electric cab-chassis work truck solution," available in multiple wheelbases, battery capacities and payloads. Zeus delivered its first 5 commercial work trucks in quarter one of 2022 and may not be able to fulfill large fleet orders initially.

Bollinger, a startup EV manufacturer from Michigan, has announced it will offer an electric truck platform that spans classes 4 through 6. However, they have not yet offered a timeline for the development of the product; it may not be produced in significant numbers until after 2030.[52]

3.5 Tier 3

Tier 3 includes a subset of on-road vehicles with niche applications or functional demands that are not able to be met by current EV technology, as well as many off-road HDVs.

3.5.1 Collection Trucks for Plowing

To date, no all-electric collection trucks are advertised with the capability to plow during the winter, potentially a reflection of the impact of cold weather on battery range and the additional time required to recharge under such conditions. During winter storms, plow trucks often operate continuously until the snow has been sufficiently cleared. NYC currently relies on garbage trucks through DSNY for its plowing function, which is a critical emergency role. DCAS anticipates testing seven electric garbage trucks for plowing functionality to gather data on the feasibility of electrifying this use case with current market offerings. In addition to the capacity of the truck, plowing effectively with electric garbage trucks will entail major investments in charging infrastructure, parking space, and backup power.

[51] Zeus Electric Chassis, purpose-built Class 4-6 electric vocational trucks. Website available at: https://zeuselectricchassis.com/.
[52] https://www.detroitnews.com/story/business/autos/2021/08/25/oak-parks-bollinger-expands-commercial-lineup-class-4-5-evs/5572732001/

3.5.2 Ladder Trucks

Ladder trucks, or aerial fire apparatus, are equipped with aerial ladders, ground ladders, and other specialized equipment needed for forcible entry, ventilation, and search and rescue tasks. No existing or announced electric ladder trucks options could be identified in the U.S. market. However, Rosenbauer announced in 2021 that it will offer an electrified turntable ladder truck model by 2023 in the European market. According to the announcement, the truck will use three electric motors, two for propulsion and one for the turntable ladder operation. The energy comes from two or alternatively three lithium-ion battery packs with a capacity of 66 kilowatt hours each.[53] Existing FDNY truck specifications are unique to its operating needs and experiences.

3.5.3 Pumper Trucks

Pumper trucks are designed to transport and dispense water and are equipped with a water tank that can hold several hundred gallons, a pump, and various types of hose.[54] Some models have been announced in 2021 for production in 2022 or 2023, and Los Angeles Fire Department placed its first all-electric unit into service in May 2022,[55] but whether they will match NYC vehicle requirements is as yet unclear. The NYC executive order on fleet electrification allows an additional five years for specialized and emergency trucks, with mandatory electrification by 2040, if suitable electric models are not available sooner. The first electric fire engine in North America was manufactured by Pierce Manufacturing in June 2021[56]; E-ONE announced it was building the all-electric Vector fire truck in November 2021.[57]

3.6 Off-Road and Specialized Equipment

Aside from the on-road vehicles discussed in prior sections, about 15 percent of the NYC fleet consists of off-road and specialized equipment.[58] This category is diverse and contains 71 distinct standard types that range from cranes to chippers. Table 7 summarizes tiered technology availability for the most common off-road standard types, while the appendix provides a full listing of all types. Figure 6 shows the distribution of the most common off-road and specialized standard vehicle types, relative to the total 4,498 pieces of off-road/specialized equipment that use fuel.

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[53] https://www.electrive.com/2021/11/01/basel-orders-4-electric-fire-trucks-from-rosenbauer/
[54] https://www.portlandoregon.gov/fire/article/275933
[55] https://www.firehouse.com/apparatus/type/pumper/news/21267741/los-angeles-fire-department-unveils-electric-fire-truck-at-open-house
[56] https://www.fireapparatusmagazine.com/features/first-electric-fire-truck-in-north-america-made-by-pierce-manufacturing-now-in-service-at-madison-wi-fire-department/
[57] https://www.e-one.com/e-one-receives-order-from-the-mesa-fire-and-medical-department-for-a-vector-north-americas-first-fully-electric-fire-truck/
[58] This figure includes only off-road or specialized equipment that use fuel. The NYC fleet also includes certain off-road/specialized equipment that do not use fuel, which are mainly trailers.

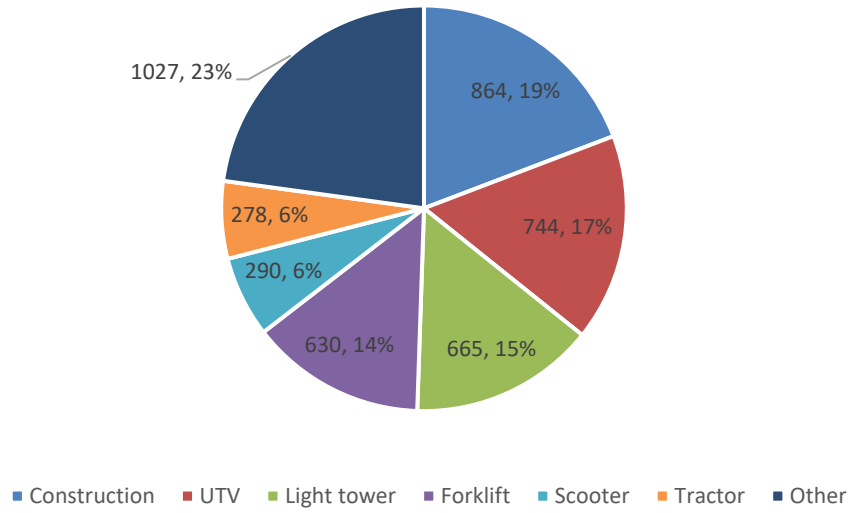

Figure 6. Vehicle Type Distribution of Off-Road Specialized Equipment

Figure 7 summarizes the penetration rates by fuel type among off-road and specialized equipment. Most (82 percent) are powered by fossil fuels.

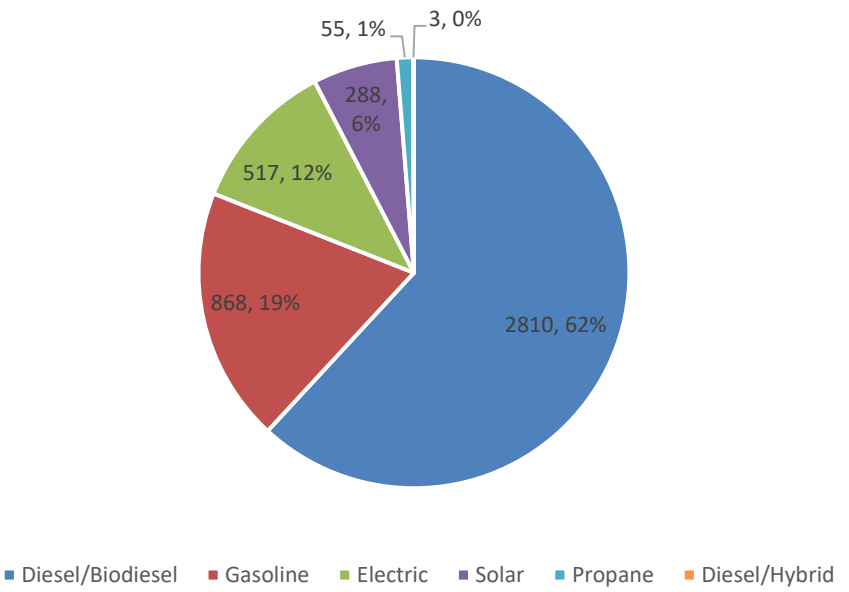

Figure 7. Fuel Type Distribution of Off-Road/Specialized Equipment

3.6.1 Tiered Technology Availability Summary for Off-Road Equipment

Volpe's preliminary market-readiness tiers analysis of off-road equipment finds that 15 percent currently have or will have models available within three years and another 66 percent are expected to have electric options within five years. Table 7 summarizes tiered technology availability for the most

common categories, while the appendix provides a full listing of all types and their tiered availability with examples.

Table 7. Tiered Technology Availability for Common Off-Road Equipment by Category

Tier	Vehicle Categories	Selected Example Vehicles
Tier 1	Compressor trailer	Atlas
	Mower – ride on	Ryobi 54" Electric Riding Lawn Mower
Tier 2	Tractors	Monarch – MK-V Solectrac – e25 Compact Electric Tractor
	Off-road utility task vehicles (UTVs)	GEM, Polaris Ranger EV, John Deere TE 4x2 Electric
	Scooters and mopeds	Piaggio – Piaggio 1 Westward – MAX EV 3
	Forklifts	Yale – Four Wheel Electric Forklift Series Toyota – Electric Forklift Series
	Light towers	Progress Solar – Solar Light Tower Wanco – Solar Light Tower
Tier 3	Most heavy construction equipment	Not currently available; typically operate far from power / EVSE

3.6.2 Tier 1

3.6.2.1 Compressor Trailer

Compressor trailers or mobile air compressors are used to power air tools or other pneumatic machinery. There are electric models on the market today in a full range of sizes, provided by manufacturers such as Atlas Copco. FDNY already has some experience with electric compressor trailers.

3.6.2.2 Mower – Ride On

Ride on mowers are used for clipping grass, and there are models currently available, from manufacturers such as Ryobi, EGO, HART, Greenworks, and Cub Cadet. Ryobi offers a 54” model for large lawns, and other manufacturers may soon offer larger models as well. DPR is already operating five electric ride on mowers.

3.6.3 Tier 2

3.6.3.1 Off-Road Utility Task Vehicles

Off-road utility task vehicles (UTVs) are small off-road vehicles that are typically used to transport passengers and equipment in situations where using a conventional vehicle may be difficult or impossible. Battery electric UTVs are readily available from well-established manufacturers (e.g., John Deere, Polaris) with a variety of configurations, tires, and accessories. About a quarter of the UTVs in the City’s fleet roster are already electrified. However, the need to plow with many UTVs is currently

limiting adoption. Current EV models do not offer plowing capacity. Range and four-wheel drive capability are also limitations for some applications.

3.6.3.2 Forklifts

Electrified forklifts are readily available on the market today from major manufacturers already represented in the City's fleet, such as Yale and Toyota. Because forklifts are used in a variety of environments and applications, they are offered in a range of form factors, and they can be easily charged since they usually operate within a facility. As a caveat, some agencies report limiting electric forklift adoption in functions where higher load capacity is required. Agencies have also expressed concern about electric forklifts in outdoor and waterfront use were exposed to weather elements.

Table 8 summarizes the vehicle counts and penetration rates of different fuels among forklifts in the NYC fleet.

Table 8. Forklift Fuel Types

Fuel Type	Count	Penetration Rate Among All Forklifts
Diesel	359	57 percent
Electric	232	37 percent
Propane	27	4 percent
Gasoline	12	2 percent

3.6.3.3 Light Towers

Light towers are mobile light sources often employed at construction sites. They consist of lamps mounted on a telescopic mast anchored to a highway-capable chassis, which houses a diesel- or gasoline-powered generator that supplies electricity to the lamps.[59] The most common electrification solution for light towers today is solar panels coupled with battery storage, which already powers about 15 percent of the light towers in the City's fleet. Battery-powered solutions without solar are also available, but less common. Solar light towers offer improved maintenance, staff savings and operational streamlining for fueling logistics, idle elimination, and programmability. These implementations are limited to use at operational locations with sufficient sun exposure.

3.6.3.4 Scooters and Mopeds

The NYPD fleet includes over 300 scooters for patrol purposes, most of which are manufactured by Piaggio or Westward Industries. These manufacturers—and many others—offer electrified models that are functionally equivalent to what is currently in the fleet, but are yet to be proven for policing operations.

[59] https://www.constructionequipment.com/light-towers-portable-light-plants

3.6.3.5 Tractors

The tractors employed by the City are largely used for mowing and horticulture applications. Electrified tractors in this segment are available for order from a few recent market entrants, notably Monarch Tractor and Solectrac. Despite their apparent market availability, tractors have been designated as Tier 2 because offerings are typically from smaller, newer companies that are still in the process of scaling up production and may be more susceptible to production delays.[60] No electric tractors have yet been tested for use in City applications, which include grass mowing and beach operations.

3.6.4 Tier 3

3.6.4.1 Heavy Construction Equipment

Currently, BEVs account for a very limited share of heavy construction equipment. Great potential for electrification within certain segments exists, but challenges such as usage patterns and performance requirements that make regular charging difficult have slowed adoption.[61] Smaller equipment, such as compact front-loaders and backhoes, have electric versions available from manufacturers such as Volvo and Case. These vehicles would be classified as Tier 2, based on market availability.

4 Strategic Considerations

This section describes overarching considerations for strategic fleetwide electrification and emission reduction, including opportunities as well as constraints and caveats. Each of the following areas will require further analysis beyond the scope of this first CFTP edition.

4.1 Understanding Vehicle Usage

An overarching theme among pilot and early fleet electrification efforts is the importance of understanding the fleet and its usage to support successful deployment. For many use cases, users may derive direct benefits from electrification above and beyond the emission benefits, such as applications that require extremely high wheel torque, or where noise reduction is important. At the same time, electrification may also introduce some constraints for certain use cases. The daily use of individual vehicles, the operating environment, their electric rates, time periods available for charging, and several other factors, such as battery capacity or range, are all part of assessing which vehicles a fleet can successfully replace without impacting service and performance.

[60] https://www.producebluebook.com/2021/11/19/monarch-tractor-secures-funding-to-complete-production-of-smart-electric-tractor
[61] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/harnessing-momentum-for-electrification-in-heavy-machinery-and-equipment

In addition to these factors, fleet agencies may benefit from understanding and addressing the gap between real-world vehicle capabilities and needs and end users' *perceptions* of those capabilities and needs. More specifically, end users often misestimate how far they typically drive, how often they need to charge, and how to conserve battery power, as they do with fossil fuels. Telematics data from platforms such as Geotab (mentioned in more detail at the end of this section) may be especially useful in this regard. Reducing the range requirements of certain BEVs, e.g., by reducing commute distances, may also ease users' range anxiety.

Some of the earliest mass-deployment of EVs has been among transit agencies operating battery-electric buses. These fleets have fixed routes operated out of a central location, which simplifies the analysis of vehicle performance requirements. As municipal, state, and private fleets begin to transition toward BEVs, they will have to develop a more detailed and data-driven representation of the "duty cycle" that each vehicle needs to perform and how it will be charged and maintained. Some vehicles may have high-mileage requirements that dictate longer range (e.g., larger batteries), or unlimited operating range (e.g., plug-in hybrid electric solutions). Specialty vehicles may serve more than one functional purpose, such as waste collection trucks that are used to plow roads during the winter. The former duty cycle is fixed-route and fixed-schedule, while plowing often requires continuous operation for days or more. Others may not return to a central maintenance or storage location and may park in available on-street parking. BEVs require reliable access to charging equipment where they are parked for extended periods of time.

This report categorizes vehicles into Tiers by their market availability. Market availability categorization is one part of clean fleet transition planning. To understand the feasibility of replacing a vehicle with electric alternatives, it is also important to understand: (1) the functional requirements of an individual vehicle based on the duties it must perform and (2) that vehicle's access to reliable charging infrastructure. Vehicles that are centrally parked and operate within known or achievable performance envelopes can be among the first targeted for electrification. More challenging applications may require operational changes, additional supporting infrastructure, or additional vehicles to maintain functionality of the existing fleet.

For example, while electric sedans are readily available, implementation can be limited by operational issues such as commuting to personal homes. The City has a large light duty fleet currently authorized for commuting. In 2022, DCAS has launched an effort to reduce fleet size and commuting. For remaining vehicles, parking areas will need to be established to enable electric charging of vehicles and central dispatch. NYC does not have a policy of allowing or reimbursing employees for charging City vehicles at private homes.

DCAS will have access to an EV suitability assessment tool within the Geotab platform, which could help to assess these issues for individual vehicle applications. This tool has the following key functionalities:

- Recommending EVs to replace current fleet vehicles that suit input parameters and preferences specified by the user, and providing reasons if a vehicle does not have a suitable replacement

- Providing a summary report of potential cost savings, fuel and electricity usage, and emission reductions

DCAS and Volpe will investigate the use of this tool for fleet planning in subsequent analyses. Additionally, there are various other tools available for assessing EV suitability.

4.2 Risk Mitigation and Product Assurances

Electric vehicle engineering entails fundamental shifts in technology and design. In general, legacy manufacturers across all segments of on-road vehicles are still at the initial stages of transitioning toward electrification, while other manufacturers are new companies without long histories of operation or vast networks for parts and service support. While new or smaller manufacturers historically drive innovation, fleets demand reliability and product support to ensure their transportation assets are available and perform their missions.

Replacement parts for high-technology components, such as motors, controllers, batteries, etc., can be expensive and may not be available or in-stock locally. New methods of constructing vehicles can bring benefits but may also require new maintenance approaches, such as the expanding use of composite materials[62] that may require different inspection techniques, compared to steel or aluminum components, to identify deficiencies or areas in need of repair.

To mitigate risk and help assure that electrified vehicles can meet expectations, contracting terms or procurement clauses may specify minimum levels of vehicle uptime or response time requirements for technical inquiries, extended warranty terms, agreements regarding future parts availability, or other terms. The terms can ideally incorporate meaningful incentives, including financial penalties, to ensure the manufacturer or vehicle source can fully support the product throughout its useful life. Contract clauses can also require vendors to provide details on how they plan to facilitate technical support, including assurances on response times and technical support availability. City-specific procurement rules and practices may restrict the City's ability to pursue some of these approaches.

4.3 Vehicle Availability

Section 3 of this report assigns vehicle categories to tiers based on market-readiness. Market conditions might complicate the process of acquiring certain vehicles. Production volumes may lag demand as highly anticipated or popular fleet vehicles are offered on electrified platforms. The Ford F-150 Lightning is one of the top candidates in this segment because it is a direct equivalent to the 267 Ford F-150s already in the City's fleet.[63] However, demand for the Lightning may outstrip Ford's production capabilities. Ford initially targeted 80,000 units in the Lightning's launch year and rapidly filled 160,000

[62] Electrification tends to add weight to the vehicle with current technology, and weight needs to be removed elsewhere to compensate for this increase, resulting in the use of lightweight composite frames, etc.
[63] NYC Fleet Roster

reservations from customers.[64] Subsequently, Ford increased its reservation cap to 200,000, and plans to ramp up production to 150,000 units by mid-2023. Ford stated that this is only for retail orders and does not include anticipated fleet sales through the new Ford Pro commercial unit.[65] Nonetheless, it is possible that DCAS might not be able to acquire these models as soon as they are available. High demand from other fleets that are competing for the same vehicles may also make procurement difficult. If fleet operators are interested in specific vehicles launched recently, or vehicles that are soon-to-be-launched, early outreach to original equipment manufacturers or contracting parties can help ensure an accurate understanding of availability. Recent supply chain issues have also impacted the schedule and delivery of vehicles throughout the fleet industry.

4.4 Vehicle-to-Load Capability

The marketplace for EVs is changing every year, with new models being offered that feature improved performance, battery capacity or range, or other features. Heavy research and development are ongoing as manufacturers vie to separate themselves from their competitors. One recent development in the LD sector has been the inclusion of vehicle-to-load capability, offered by recently developed 800-volt battery architectures. These capabilities allow a user to plug in devices that would typically be plugged into a 120-volt socket and power them from the vehicle's onboard battery. Some models, such as Hyundai's Ioniq 5, can provide an emergency charge to another EV. Many agencies use light equipment such as weed whackers, leaf blowers, and lawn mowers. The City operates over 10,000 such units, especially at agencies like Parks and NYCHA. The ability to charge these equipment units through the vehicle could greatly support electrification of these equipment units that currently rely on gas.

In the future, vehicles will likely feature the ability to power various devices, provide backup power for buildings, and eventually, will allow the utility to access the vehicle's stored energy to offset facility power consumption during high-demand times. For example, school buses are prime candidates for use in peak load management situations as they have large batteries and set schedules. This ability would require charging infrastructure that supports bidirectional power. As the market continues to evolve, more vehicles and charging solutions will offer bidirectional capabilities or support vehicle-to-everything (V2X) applications, and these features may offer benefits in certain fleets.

4.5 Idle Reduction

Interim measures exist to minimize the fuel consumption and emissions of certain fleet units that cannot be electrified in the short term. Idle reduction is an interim measure with likely applications for Tier 2 and 3 vehicle categories such as fire apparatus, Parks Department chipper and bucket trucks,

[64] https://www.cars.com/articles/electric-outage-2022-ford-f-150-lightning-reservations-full-maverick-hybrid-sold-out-444930/
[65] https://www.autonews.com/automakers-suppliers/fords-f-150-lightning-production-capacity-will-nearly-double

NYCDOT's Vision Zero van, and others. FDNY and DCAS have implemented a major idle reduction program for City ambulances.

Volpe research points to several solutions for reducing idling that DCAS could consider. Aftermarket hybridization by Odyne, Lightning, XL Hybrid, etc. is one approach. Two Clean Cities Coalitions that Volpe consulted independently recommended another approach, an anti-idling platform that can fit many vehicle weight classes and address a range of load types.[66] Additionally, dozens of other commercially available idle management, heating, cooling, APU, power take-off, cargo refrigeration, and wayside power solutions are catalogued in Argonne National Laboratory's (ANL's) "Idling Reduction Technology Solutions for Class 1–8 Vehicles" database.[67] Analysis of telematics data is a best practice to identify the idling durations and patterns of Tier 2 and 3 fleet units to estimate the emission reduction benefits of idling reduction measures and to prioritize units for near-term modification. Discussing the causes of idling with the relevant agencies can clarify what operations lead to idling and help identify the optimal idle reduction technology for each fleet unit. Below is a selection of idle reduction technologies from the ANL database applicable to MDHD vehicles.

Table 9. Idle Reduction Technologies from the ANL Database

Company	Product	Estimated Fuel Use gal/hr (Mfr. Estimate)	Estimated Cost (low end)	Estimated Cost (high end)	Website
Autotherm	No-Idle Cab Heating System (T2500 and T2524)				http://www.autothermusa.com/index.html
Canadian Extreme Climate Systems Ltd	GRIP Idle Management		$2,000	$10,000	https://www.gripidlemanagement.com/
Eberspaecher	Airtronic Heater (D2)	0.02-0.07	$900	$900	https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html
Eberspaecher	Airtronic Heater (D4)	0.03-0.13	$900	$900	https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html
Eberspaecher	Airtronic Heater (D5)	0.04-0.17	$900	$900	https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/air-heaters.html
Eberspaecher	Hydronic Coolant Heater (D5)	0.07-0.16	$1,250	$1,250	https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/coolant-heaters.html
Eberspaecher	Hydronic S3 E coolant heater	0.15-0.17	$900	$1,500	https://www.eberspaecher-na.com/products/fuel-operated-heaters/product-selection/coolant-heaters/hydronic-s3.html
Idle Smart LLC	Idle Smart		$1,500	$2,500	http://idlesmart.com/#home
InterMotive Vehicle Controls	Eco-Star™	0.6	$800	$900	http://www.intermotive.net/Brochures/EcoStar_brochure.pdf
InterMotive Vehicle Controls	EcoLock	0.6	$630	$630	http://www.intermotive.net/Installation%20Instructions/Eco%20Lock/ECL554-A-061517.pdf
Smart Power Solutions	Stealth Power	0.60- 2.5	$4,295	$19,995	http://www.idlereduction.com/

[66] https://gripidlemanagement.com/
[67] https://www.anl.gov/sites/www/files/2020-09/Idling%20Reduction%20Technology%20Solutions%20for%20Class%201-8%20Vehicles%209-2020.pdf

Temp-a-Start	Temp-a-Start System		$1,750	$2,500	http://www.temp-a-start.com/
Vanner	IdleWatch		$1,588	$1,588	http://www.vanner.com/idlewatch-for-engine-off-acdc-power-for-work-trucks/
Webasto	Thermo Top C	0.08-0.16	$1,415	$1,415	https://www.webasto.com/gb/markets-products/truck/heating-systems/products/thermo-top-c/
Webasto	DBW 2010	0.4	$3,315	$3,315	https://www.webasto.com/us/markets-products/heavy-duty-truck/heating-systems/products/dbw-2010/
Webasto	Air Top 2000 ST	0.03-.06	$1,800	$1,800	https://www.webasto.com/us/markets-products/heavy-duty-truck/heating-systems/products/air-top-2000-st/

NYC installed fuel-fired cabin heaters on 90 salt spreaders around 2011 that proved to be high maintenance, but the technology has improved since then. Fuel-fired heaters may be an effective solution for occupied vehicles such as salt spreaders that are idled in place before a snowstorm.

Beyond an idle-management system, cabin heater, or other anti-idle solutions in the ANL database, neutral at stop can reduce idling emission on MD and HD vehicles. The Allison FuelSense 2.0 transmission option reduces or eliminates the load on the engine while the vehicle is stopped with service brakes engaged—for example, at red lights or during trash stops--reducing fuel usage and emission.[68] According to NYC Sanitation, neutral at stop produces 3-4 percent fuel savings. Allison Transmission claims savings of 6 percent for refuse packers.[69] FuelSense 2.0 is available on Allison transmissions across most, if not all, heavy truck and bus types, as detailed in the transmission manufacturer's Vocational Model Guide. Other diesel trucks, such as dump trucks, could also be equipped with neutral at stop, though the fuel efficiency benefit would likely not be as large as for packers, which make more frequent stops. Neutral at stop has been available since 2014 on Freightliner M2-106 with Allison 1000/2000/3000/4000 series transmissions.[70] Neutral at stop became standard in 2020 on International MV medium-duty trucks, successor to the International 4000-series.[71]

NYC Sanitation has piloted an aftermarket engine stop-start system for HD diesel engines.[72] It is an electric system designed to shut down the engine of vocational trucks when they are stationary and to provide electric power to the vehicle equipment, cab and chassis accessories including the heating, ventilation, and air conditioning (HVAC) system. For new vocational vehicles, Allison Transmission has announced an automatic 9-speed transmission with integrated engine stop-start system with vehicle hold, "targeted for global release by 2022."[73] DCAS intends to assess the return on investment for these type of investments before pursuing them, as they substantially increase vehicle costs.

[68] https://www.allisontransmission.com/why-allison/fuelsense
[69] https://www.fleetowner.com/equipment/article/21695614/allison-unveils-fuelsense-20-software-upgrade
[70] https://www.government-fleet.com/116862/freightliner-adopts-allison-s-fuelsense-for-fuel-efficiency; https://www.todaystrucking.com/allison-boosts-fuel-savings-with-software/
[71] https://www.marketwatch.com/press-release/international-truck-to-feature-allison-neutral-at-stop-as-standard-equipment-on-the-2020-international-mvtm-series-2019-10-16
[72] https://www.effenco.com/
[73] https://www.allisontransmission.com/company/news-article/2019/05/20/allison-transmission-to-showcase-next-generation-9-speed-automatic-transmission-at-brisbane-truck-show

4.6 Vehicle Rightsizing and Segmenting

Vehicle electrification is most advanced in the lighter GVWR classes, and as a result, the greatest number of EV model choices are in the LD segment. Revising the City's fleet mix to right size vehicle types wherever the replacement model still meets the mission can be a way to accelerate the transition to all-electric while also advancing the goals of Mayoral Executive Order 41 of 2019, Mayoral Executive Order 90 of 2021, and Mayor Adams Fleet Reduction and Efficiency Initiative announced in April 2022.[74] Even where all-electric options exist for larger vehicle types, rightsizing or downsizing to vehicle platforms that still perform the mission can provide benefits in terms of greater operational efficiency, reduced unit cost, reduced lifecycle environmental impacts, and improved road safety for vulnerable road users. Given the additional weight of EVs, rightsizing may also prevent certain unintended consequences of electrification. For example, the unladen weight of large electric pickup trucks on the market today can exceed 6,000 pounds,[75] which could require these vehicles to be registered as commercial vehicles[76] and potentially restrict their access to the New York City parkway system.[77] At the same time, downsizing without regard to functional requirements could result in disbenefits such as lack of adequate storage space or passenger seats.

Segmenting any Tier 2 or Tier 3 vehicle categories into groups by their daily use and duty cycle may create additional near-term electrification opportunities. For example, segmenting Correction prisoner transport buses into local and long-distance categories could move the local transport buses into Tier 1, as electric school and transit buses are already widely available and could likely meet operational requirements. Traditional-use SUVs could potentially be segmented by interior volume requirements, allowing electrification sooner with crossover, hatchback, or sedan EV models that meet the requirements. Downsizing from traditional SUVs to smaller, lower-profile vehicles can also yield safety benefits in support of NYC Vision Zero and the Safe Fleet Transition Plan. Crashes are 2-3x less fatal for vulnerable road users when the striking vehicle is a passenger car compared to an SUV or pickup truck due to their less aggressive front-end designs, and a recent study finds that SUVs and pickup trucks are more likely than a passenger car to be involved in a turning crash with pedestrians. DCAS has begun efforts to reduce the number of SUVs through Mayoral Executive Order 90 of 2021 and will seek to continue those efforts as part of both its electrification and Vision Zero safety initiatives and Mayor Adams Fleet Efficiency and Reduction Initiative.[78]

Since pickup truck engine power and efficiency have both increased over the past decade, one strategy for reducing fuel consumption from plowing pathways and bike lanes can be to reduce future model year power requirements to match older in-service vehicles (such as 2008 models). At least one

[74] https://www1.nyc.gov/assets/home/downloads/pdf/executive-orders/2019/eo-41.pdf
[75] https://tfltruck.com/2022/01/news-2022-ford-f-150-lightning-weighs-less-than-you-may-think/;
[76] https://dmv.ny.gov/forms/mv114.pdf
[77] https://www1.nyc.gov/nycbusiness/description/commercial-vehicle-restrictions
[78] https://www.iihs.org/news/detail/new-study-suggests-todays-suvs-are-more-lethal-to-pedestrians-than-cars, https://www.govinfo.gov/content/pkg/FR-2015-12-16/html/2015-31323.htm; https://www.iihs.org/news/detail/suvs-other-large-vehicles-often-hit-pedestrians-while-turning

snowplow option is now available for F-150s with a V-6 engine, for example, and the manufacturer advises that sufficient electrical power is more critical than horsepower or torque. The City of Denver uses F-150s for plowing bike/walking paths, and the City of Cambridge, Massachusetts uses a Chevy Colorado for plowing bike lanes. Downsizing pickups from Class 2b-3 to Class 2a could open the possibility of fully electrifying non-street plowing sooner, since both Ford (2022) and GM (2024) offer near-term electric pickups that may offer plow packages. Plug-in hybrid conversion of F-150s/250s may be another, more immediate strategy and would provide ample electrical power.

For non-plowing pickups used to haul smaller items, Ford offers the new 2022 Maverick model, a compact Class 1 pickup that is currently a HEV and may soon be offered as a BEV. Additionally, Pickman offers low-speed-vehicle electric mini pickups of similar size to the gasoline-powered units currently operated by NYCHA, in standard bed, crew cab, and "mission" box configurations.[79]

4.7 Employee Driver Education

City employee drivers can follow certain best practices to increase the in-service performance of an all-electric fleet throughout the year and meet agency mission requirements. According to one analysis, real-world EV range at any given temperature can vary by approximately a factor of two, depending on external factors including terrain, speed, driver habits, trip length and start-conditions (e.g., if the trip started in a climate-controlled garage).[80]

Some eco-driving techniques for extending EV range are the same as for ICE vehicles. However, DCAS may choose to educate staff that there are additional best practices for operating as well as storing EVs to maximize their operating range and battery longevity.

4.7.1 Operating Practices

- **Avoid letting the battery charge get too low.** An EV's battery management system reserves a certain percentage of the battery capacity – generally about 15-20 percent – to heat or cool the battery within an efficient operating temperature range.
- **Heat the passenger, not the cabin.** Heating the full cabin in cold weather can drain an EV battery and reduce range. Operators can restrict heating to just the driver, whether by turning air vents on or off or controlling seat or steering wheel heating settings. Heating the cabin air can draw 3000-5000 watts and is less efficient than heating the seat and steering wheel, which draw around 75 watts. Using these increasingly common features can maintain comfort without the cabin heater.[81]

[79] https://www.thepickman.com/
[80] https://www.geotab.com/blog/ev-range/
[81] https://www.geotab.com/blog/ev-range/

- **Use Eco-Mode.** Most EVs have a form of "eco-mode" that boosts range and reduces power consumption by limiting the energy supplied to the driving motor and cabin heaters. Operators may accelerate more slowly, but this behavior can also make driving safer in icy or snowy conditions.[82]
- **Use regenerative braking and avoid unnecessary harsh braking.**[83] EVs are equipped with a regenerative braking system that enables the driver to actively save energy in deceleration maneuvers, but they work best when drivers slow down well in advance, while those who speed up to a stop and decelerate suddenly see the least amount of efficiency. With practice, drivers may be able to drive using only the throttle, letting the regenerative braking slow or stop the vehicle, in what is referred to as "one-pedal driving."[84]

4.7.2 Storage Practices

- **Park EVs in moderate temperature locations.** Storing EVs inside during winter can make a difference in battery performance. The moderate temperature of a garage can help batteries charge for longer and charge more quickly. Extreme high temperatures can negatively affect battery life. Staff can minimize these effects by parking EVs in the shade, out of direct sunlight, during the summer. However, potential safety hazards of storing EVs indoors may exist, which are not yet fully understood.
- **Pre-condition plugged-in EVs before driving.** Turning on a plugged-in EV's heater or air conditioning to warm (or cool) the cabin to the desired temperature before starting a trip will result in several benefits. Doing so will minimize the auxiliary load on the battery, make the trip more comfortable for the operator, and improve range. Some EVs come with apps that allow staff to start preconditioning remotely. Note: if the option is available, parking an EV in a temperature-controlled garage achieves the same effect.
- **Keep EVs plugged in on extreme cold or hot days**. In addition to the benefits of preconditioning, original equipment manufacturers recommend vehicles are kept plugged in during very hot or very cold days when the vehicle is not in use. (Note: this is not the same as actively charging, which is better to avoid in extreme conditions, particularly heat). Having a vehicle plugged in allows the internal system to maintain battery temperature controls, prolonging the life of the battery.

4.7.3 EV Education for Service Professionals and Emergency Response Officials

- NYC employs over 1,400 service professionals including mechanics, service workers, tow truck operators, parts professionals, and fleet managers. DCAS launched in 2021 a training and shop equipment initiative to help transition mechanical staff and garages to the challenges of EV maintenance. In general, EVs will reduce overall maintenance needs. However, the large

[82] https://electrek.co/2021/10/15/6-ways-to-get-the-best-range-from-your-electric-car-in-winter/
[83] https://www.humanist-vce.eu/fileadmin/contributeurs/humanist/Vienna2014/Neumann.pdf
[84] https://driving.ca/column/how-it-works/how-it-works-regenerative-braking

batteries, regenerative braking, and engine computer functions of EVs will require retraining for technicians.

- The large EV batteries also pose a potential new risk in vehicle crashes for staff who respond including law enforcement, EMTs, fire fighters, mechanics, and tow truck operators. DCAS Fleet could partner with the FDNY and reference guidance from the National Transportation Safety Board and the National Highway Traffic Safety Administration to establish response protocols and education for response officials.[85]

4.8 Electric Vehicle Supply Equipment (EVSE)

Operational success of EVs is inherently tied to the electric vehicle supply equipment (EVSE) required for charging. Fleets and charging solutions can vary widely, may or may not include hardware of similar brand or type, and often must accommodate multiple vehicle types. Fleet operators can engage in long-term planning and analyses to inform their charging requirements and site development, considering risk mitigation solutions when considering hardware selection, charging management, demand reduction strategies – including on-site energy storage systems, potential on-site renewable energy (e.g., solar), and emergency back-up or resiliency solutions. Mission-critical and emergency response vehicles may require robust resiliency solutions, whereas general use fleets may have less need to assure operational continuity.

4.8.1 Charger Types and Hardware Selection

Level 1 charging relies on any wall outlet providing 120 volts and is capable of replenishing 2-5 miles of range per hour. Level 1 is most used for at-home charging but is also suitable for applications where limited numbers of LDVs are parked for longer periods of time, such as public or employee parking at low-trafficked sites or those without 240-volt electrical systems.

Level 2 charging requires 240 volts and replenishes 10-20 miles of range per hour. Typically, stations can collect data and communicate with charge management solutions and network providers. Level 2 charging is the preferred choice for most LD fleet applications, public charging sites, and in applications where managed charging, payment systems, or reporting is required.

Level 3 Direct Current Fast Charging (DCFC) requires 480 volts and can replenish 120-160 miles of range per hour, collect data, and communicate with charge management solutions and network providers. Not all EVs can charge at DCFC equipment. Typically, DCFC is employed when vehicles require faster charge rates, or when vehicles may have limited available time to charge. Often this may be the case for larger

[85] https://www.ntsb.gov/safety/safety-studies/Documents/SR2001.pdf; https://www.nhtsa.gov/sites/nhtsa.gov/files/811575-interimguidehev-hv-batt_lawenforce-ems-firedept-v2.pdf

vehicles. Also, DCFC are commonly employed on long distance routes, such as at rest areas on highways, relevant to NYC vehicles that travel to Albany or other distant sites.

Table 10 summarizes the above, showing each level's voltage and charging speed.

Table 10. Summary of EV Charging Speeds

Level	Voltage	Miles of Range Added Per Hour of Charging
1	120	2 to 5
2	240	10 to 20
3	480	120 to 160

Light-duty vehicles (LDVs) used infrequently or parked for long periods of time, like most privately owned vehicles, can often be served by Level 1 solutions. However, most commercial or fleet-level charging strategies rely on Level 2 charging even for lower power applications, as Level 2 chargers can collect data and communicate so fleet managers can be more informed. When a vehicle is parked for long periods of time, this allows the operator to charge the vehicle at lower charge rates over longer durations and as a result, reduce electrical power demand and associated costs. Various charge management solutions can dynamically manage charging or ensure vehicles are fully charged by a pre-determined time so they can start their day, while allowing the flexibility to ensure lower charge rates if time allows. The most elegant solutions can incorporate rate curves from specific utilities, spread charging out over available time, and dynamically manage charging rates and schedules to ensure vehicle charging occurs during periods of low demand whenever possible.

Hardware solutions for fleets include plug-in Level 1 and Level 2 chargers that can be wall- or pedestal-mounted, plug-in or overhead, automated DC fast charging, and mobile charging solutions.[86] Wireless charging systems are available for some at-home charging applications and are being tested for HDV charging; these higher-end systems eliminate the need for a staff person or driver to physically plug in vehicles, offering potential labor cost savings and safety benefits by eliminating cords and tripping hazards. However, wireless charging systems are not commonly being deployed for fleet applications. Plug-in systems generally cost less than overhead[87] or wireless systems. However, they often result in reduced parking capacity as the chargers require space and clearance. Fleets with limited parking may wish to pursue overhead charging solutions that feature either drop-down plug-in charging cords or automated mechanized coupling systems. Locating hardware above parking areas preserves ground-level space needed for parking and vehicle access. Wall mounted solutions are often the cheapest to install, followed by pedestal-mounted chargers and drop-down overhead chargers.

[86] New Flyer 2021 Charger Catalog (third-party hardware): https://www.newflyer.com/site-content/uploads/2021/01/2021-Charger-Catalog.pdf.
[87] For example: https://www.masstransitmag.com/bus/maintenance/power-converters-battery-chargers-and-inverters/press-release/21152126/vapor-bus-international-a-wabtec-corp-ets-installs-indepot-pantographs-to-charge-electric-buses

Hardware selection may impact energy consumption; Energy Star rated products[88] can reduce energy consumption, costs, and emissions in cases where energy supply is not 100 percent clean energy.[89] All Energy Star rated products are fully tested for safety and energy use, verified by nationally recognized independent certification bodies, and use industry network communication standards.[90] EnergyStar provides reference language for contracting personnel to consider in their procurement activities.[91]

Alternative solutions to static EV charging stations also exist. Third-party companies offer mobile charging solutions, where a charger and battery are deployed on demand to a given vehicle's location to refuel it. [92, 93] Ample, a San Francisco-based startup, offers modular battery swapping services for EVs that remove discharged battery modules from the vehicle and replace them with fully charged ones in less time than it typically takes to refuel using typical methods.[94]

4.8.2 Operational Considerations

Early deployments of EVs have focused on the most suitable use cases; specifically, vehicles that operate along fixed routes, or within known constraints, and return to base at the end of their shift. Whether or not vehicles return to the same parking area each night is the primary consideration for EVSE planning and implementation. For such vehicles, the next consideration is typically the vehicle's operational schedule. What times the vehicle is parked and for how long greatly influences the optimal charging solution. As mentioned previously, DCAS will have access to an EV suitability assessment tool within the Geotab platform, which could help to assess these issues for individual vehicle applications; section 4.1 includes further details. DCAS and Volpe will investigate the use of this tool for fleet planning in subsequent analyses.

At one point or another, fleet units will have to interact with different EVSE, charge at alternate locations, or operate through software updates to either vehicles or chargers that may pose challenges if not coordinated or planned for. Agreements with EVSE suppliers and EV vehicle providers can include clauses or protocols to ensure any updates to vehicle or EVSE systems do not cause operational issues, e.g., when a charging system updates its software, vehicles may need subsequent software updates, or vice versa. Fleets may wish to ensure a policy exists to manage changes that may affect multiple systems.

Fleet managers with vehicles across locations or those that rely on public or third-party chargers may benefit from charging management software that enable payment and reporting across various charging equipment or providers. Fleets with their own dedicated EVSE may benefit from charging management

[88] https://www.energystar.gov/productfinder/product/certified-evse/results
[89] https://www.energystar.gov/products/other/ev_chargers
[90] https://www.energystar.gov/products/ask-the-experts/tips-on-electric-vehicles-and-chargers-with-energy-star
[91] https://www.energystar.gov/sites/default/files/asset/document/Final_Procurement_Language_for_EVSE.docx
[92] https://lightningemotors.com/lightning-mobile/
[93] https://www.sparkcharge.io/roadie
[94] https://ample.com/how-it-works/

solutions that focus on reducing the electrical load and reducing demand while ensuring vehicles are fully charged when they are needed.

While offering advantages, charging management software introduces additional monthly costs and risks relating to disruptions to software networks. Fleets should consider requiring that chargers can operate in a failsafe or "dumb charger" mode, without the software. There may also be fleet applications where stand-alone non-networked chargers fulfill operational requirements.

In applications where a vehicle may not return to base, route analyses can help inform energy consumption, identify nearby charging or EVSE, establish gaps in coverage or required charging speeds, plan for development of charging networks or corridors where needed, and establish a baseline from which to plan mitigation strategies. Short-term gaps in EVSE availability can be addressed with mobile charging solutions that include energy storage[95] or from mobile power generators fueled by a liquid or gaseous fuel.[96] Long-term solutions entail installation of chargers near known routes or electrifying road corridors via overhead wires[97] or embedded wireless systems[98] that can charge vehicles as they drive.

Installed charging solutions will require policies for access and payment, especially if some locations allow employees to charge their personal vehicles, in addition to fleet charging. Physical access may be restricted for certain locations, such as private parking lots or fleet depots. All locations should consider the potential vehicle types that may require access (e.g., ensure sufficient space for maneuvering of larger vehicles for charging stations they may need to use).

4.8.3 Resiliency and Cybersecurity

For fleet charging of vehicles that are mission-critical, resiliency planning in coordination with the local utility may warrant requirements for continuity of charging during power outages. On-site energy storage systems (large stationary batteries) and backup power generators fueled by gasoline, diesel, natural gas, or propane can provide varying levels of continuity during power outages. Solutions will depend on the needs of the fleet and the potential timeframe to plan for power outages (e.g., short-term vs. long-term power outages). DCAS is the nation's largest adopter of freestanding solar carports, which use solar panels and large batteries to provide emergency-resilient, off-the-grid charging.

In addition to the concerns mentioned previously, the cybersecurity of EVSE is an important consideration. Cybersecurity incidents can present a barrier to EV adoption, threaten critical infrastructure, and impact the City's ability to deliver critical services and supplies. Implementing

[95] Examples include Lightning Mobile EVSE, https://lightningemotors.com/lightning-mobile/; Xos mobile charging trailer, https://www.pv-magazine.com/2021/08/13/portable-charging-trailer-for-commercial-ev-fleets/.
[96] Larson Electronics (among other providers) offer smaller generators for LD applications, https://www.larsonelectronics.com/product/275062/portable-electric-vehicle-charging-station-30a-level-2-charger-single-port-12kw-gas-propane-generator.
[97] https://www.cleanenergywire.org/factsheets/electric-highways-offer-most-efficient-path-decarbonise-trucks
[98] https://www.ttnews.com/articles/first-us-mile-wireless-ev-charging-road-coming-detroit

cybersecurity best practices and physically securing EVSE to prevent tampering are therefore crucial. [99] Fleet operators can also press their EVSE suppliers to understand whether "failsafe" options exist for the charging in the case of a compromised or disrupted network. For mission-critical operation, DCAS may wish to require chargers to include a manual mode enabling use with or without network services.

The federal government has several publicly available resources on this topic. The Federal Energy Management Program has published risk mitigation techniques and procurement recommendations for EVSE that address both physical and remote threats.[100] A 2019 report by the National Renewable Energy Laboratory explores risk mitigation techniques in more detail, as they vary by communication standard used.[101] Volpe has also previously published a report on cybersecurity best practices and related procurement considerations for public fleets.[102]

4.9 Nexus between Clean and Safe Fleets

The CFTP technologies that reduce fleet unit emissions can also affect fleet safety. The reverse is true for SFTP safety technologies that can affect vehicle fuel consumption and emissions. Examples of technologies that may lie at this nexus include speed limiters and intelligent speed adaptation, which can both reduce fuel consumption and reduce speeding-related crashes; aerodynamic side guards that can save fuel and protect other road users in certain collisions; adaptive cruise control; automatic tire inflation systems; and others. In some cases, the safe-clean nexus may be operational. For example, the reduction of noise from EVs can make it possible to operate them at off-peak hours when exposure to other road users is reduced, potentially reducing crash risk.[103] The design of electric trucks, without a conventional engine block, may increase opportunities to implement high vision cabs. At the same time, EV post-crash response may introduce new risks that will need to be considered and mitigated. Further research may also be needed to understand the effects of electrification at different vehicle weight classes on tire and brake particulate pollution, and electrification's effect on the ability of people with visual impairments to hear and safely navigate around medium- and heavy-duty EVs. Volpe will undertake an analysis of the potential safety effects of CFTP- and SFTP-specific technologies and develop best practices that DCAS and fleet agencies can take to minimize new safety risks, minimize emissions, and best align the clean fleet transition with the City's Vision Zero objectives.

[99] https://www.energy.gov/sites/default/files/2021-06/elt198_johnson_2021_o_5-11_558pm_LR_TM.pdf
[100] https://www.energy.gov/eere/femp/federal-fleet-cybersecurity
[101] https://www.nrel.gov/docs/fy19osti/74247.pdf
[102] https://rosap.ntl.bts.gov/view/dot/43606
[103] http://www.nyc.gov/html/dot/downloads/pdf/off-hours-delivery-overview.pdf

4.10 End-of-Life Disposal

At time of writing, the United States does not have federal mandates related to EV battery recycling or reuse. The U.S. Department of Energy has a Battery Recycling Prize[104] competition that aims to provide funding for lithium-ion recycling technology development and is beginning pilot validation phases. The U.S. Department of Energy also initiated the ReCell Center[105] to help develop the domestic recycling industry. Some states are planning to implement policies that are likely to outpace federal action. Suppliers of large EVs may offer stationary energy storage systems designed to accommodate battery modules from their vehicles and to enable repurposing of vehicle batteries for stationary applications where energy density or total battery capacity requirements are less stringent. For example, since stationary batteries are not moved, weight is less of a concern. However, system designs are not standardized to facilitate a universal application of energy storage achieved with repurposed EV batteries. Current systems must be designed for a particular battery pack or module.

If repurposing is not an option, fleets can ask their vehicle manufacturer(s) for approved battery recycling centers. No formal New York State policy addressing the recycling of EV batteries was identified at the time of this writing. However, Li-Cycle Corp recently opened a commercial scale recycling plant in Rochester, NY.[106]

Vehicles sent for disposal may require safety procedures or de-energizing of the battery systems prior to disposal, per manufacturer-supplied guidance for emergency transport and disposal protocols. DCAS has limited experience to date with auctioning of BEV vehicles at useful life but expects to conduct BEV auctions in the next two years.

[104] https://americanmadechallenges.org/batteryrecycling/
[105] https://www.anl.gov/article/doe-launches-its-first-lithiumion-battery-recycling-rd-center-recell
[106] https://li-cycle.com/news/li-cycle-announces-commercial-lithium-ion-battery-recycling-plant-now-operational-in-rochester-new-york/

5 Conclusions

In three parts, this CFTP document frames the existing strategies and progress of City agencies in electrifying fleets, the availability and readiness of EVs for operation in agency fleets, and strategic considerations for the transition to all-electric as well as intermediate steps.

Volpe's analysis of the DCAS fleet roster of over 29,500 fleet units found that existing vehicle electrification varies significantly by agency, with three agencies having surpassed 10 percent share of BEVs, while seven agencies are currently below 5 percent, as of the roster publication. When including PHEVs, one agency fleet is already majority plug-in.

Volpe held discussions with Cityagencies that will play a key role in the clean fleet transition. The discussions identified both opportunities and challenges related to fleet operational needs, charging infrastructure needs, and experience with EVs and other technologies.

Opportunities

- Sedans, vans, lighter pickups, and buses used for passenger transport are a prime segment for electrification.
- Multiple agencies report idling their vehicles to power auxiliary equipment that could run cleanly off an EV battery.
- Downsizing vehicles to smaller platforms, such as from SUVs to sedans or hatchbacks, can make it possible to electrify those fleet units sooner due to the greater market availability of smaller EVs, with potential efficiency and safety benefits.
- First responders and emergency services report a need for charge times under 30 minutes, while most other agencies did not report this as a priority.
- Interim fuel efficiency solutions are concentrated among agencies with specialized, HDVs that are not currently electrified.

Challenges

- All agencies perceive an overall shortage of charging stations.
- PHEVs are popular among multiple agencies that have started electrifying their LD fleet, but not all agencies are consistently charging them.
- Some agencies with HD trucks report hesitance to test new BEVs and prefer non-plug-in hybrid electric vehicle (HEV) or EV retrofits.
- Some agencies report cargo space needs to transport specialized equipment and foresee challenges with downsizing certain vehicles if doing so reduces the cargo space.
- As electrification expands, there will be a growing need for resilient charging solutions including backup power options in case of power outages.
- Plowing and off-road (4x4) functions limit electric adoption.

In concert with DCAS, Volpe defined three EV market-readiness Tiers and mapped these to vehicle categories represented in agency fleets, including a comprehensive analysis for on-road vehicles and a preliminary analysis for off-road vehicles. Note that the Tiers do not account for current or future constraints associated with charging infrastructure or reflect the specific requirements of City and DCAS procurement practices. It is not the intention of Volpe or DCAS to endorse any specifical products or manufacturers mentioned in this report. However, the Tiers provide a vehicle-side transition planning tool based on expected market availability within 0-3 years for Tier 1, 3-5 years for Tier 2, and greater than 5 years for Tier 3.

Volpe analysis finds that 41 percent of existing on-road agency vehicles are in a Tier 1 category and can be prioritized for the transition to electric either immediately or within three years. These include cars, LD pickup trucks, passenger and cargo vans, non-plowing collection trucks, school and transport buses, Type 2 and 3 ambulances, and mobile command centers. **Another 43 percent of all agency vehicles fall under Tier 2 and could be electrified within five years**, based solely on expected EV market availability. Tier 2 includes police and non-police SUVs, Type 1 ambulances, minivans, heavier pickup trucks. **The remaining 16 percent of vehicles that are in Tier 3 are expected to not be market-ready for electrification within five years**, including collection trucks used for plowing as well as fire ladder trucks and pumper trucks. DCAS may need to prompt and work with manufacturers to develop and test suitable offerings for the Tier 3 vehicle types. Given the lifecycle of these HD fleet units, strategically considering other emission reduction technologies for these vehicles will be important as interim steps to still advance toward the City's zero emission fleet target.

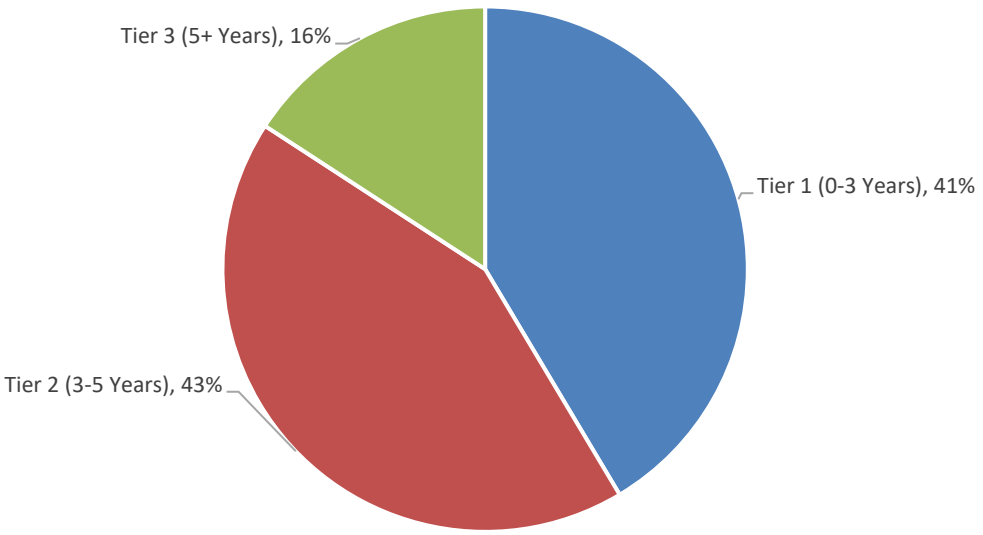

Figure 8. Percent of On-Road NYC Fleet Units by Assigned CFTP Tier

Aside from the on-road vehicles discussed in prior sections, about 15 percent of the NYC fleet consists of off-road and specialized equipment. Volpe's preliminary market-readiness tiers analysis finds that **15**

percent have models available within two years and 66 percent are expected to have electric options within five years. Figure 9 summarizes these percentages.

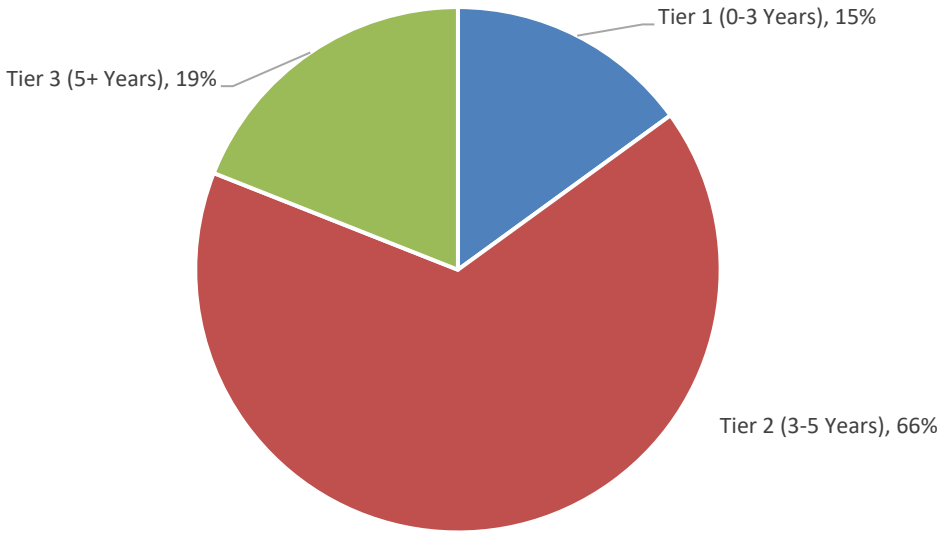

Figure 9. Percent of Off-Road Fleet Units by Assigned CFTP Tier

Careful planning is the best risk mitigation tool for successfully transitioning a fleet to all-electric. Among the factors that fleet operators need to consider are:

- the daily use of individual vehicles
- the operating environment
- their electric rates
- time periods available for charging
- battery capacity or range.

These factors should be assessed as part of understanding what vehicles can successfully be made electric without impacting service and performance.

Complementary strategic considerations that Volpe has identified include:

- vehicle segmentation by usage requirements
- rightsizing to smaller vehicle platforms to accelerate electrification wherever possible and realize other benefits
- City driver education about several new best practices that will help maximize the range and longevity of electric fleet units
- addressing idle reduction for MD and HD vehicles
- using telematics analysis and fleet interviews to identify the right technology solutions

DCAS and Volpe will prepare updates to the CFTP every two years to keep pace with market change. Volpe will propose to DCAS additional potential areas for analysis as part of the 2024 CFTP update cycle, as well as potential further analysis of the strategic considerations in Section 4. New areas could include:

- An updated round of fleet discussions with agencies regarding progress in electrification, electrification needs and challenges;
- Assessment of the appropriate type, quantity, and distribution of EVSE solutions;
- Greenhouse gas inventory breakdown to identify largest emission sources and vehicle groups;
- Operations, maintenance, and cost analysis, (total cost of ownership, TCO) including charging infrastructure;
- More detailed assessment of end-of-life options for EVs;
- Safety effects of clean fleet technologies including new EV models (see section 4.8.1 for an initial discussion with examples);
- Assessment of environmental benefits of EV adoption in NYC as impacted by the emissions of source electricity and related areas such as vehicle brake and tire emissions, which may be affected by heavier EVs and regenerative braking;
- Procurement research for focus group vehicles; and,
- Opportunities to extend these initiatives to private fleets as regulated by City local laws and City charter, in the same manner that safety initiatives such as crossover mirrors[107] and truck side-guards[108] have been extended.

[107] http://rules.cityofnewyork.us/wp-content/uploads/2021/03/BIC-Final-Rules-Regarding-Traffic-and-Vehicle-Safety.pdf;
[108] https://www1.nyc.gov/assets/bic/downloads/pdf/regulations/local-law-108.pdf

Appendix A: DCAS Standard Types Tiers

While this report uses several broad vehicle categories for the main tier designation in Table 1/Table 6 and the associated discussion in Section 3, DCAS categorizes its fleet roster into 191 standard types. The subsections in this Appendix A map these standard types to their respective tier designations. An additional "not applicable" category shows equipment that does not use fuel.

A.1 On-Road Tier 1 Standard Types

Type	Count	Tier	BEV Models	DCAS Notes
BUS - 25-39 PASSENGERS	9	1	Collins Bus Corporation (Type A school bus / F450) Lightning eMotors (multiple chassis and body types), Motiv Power Systems (multiple chassis and body types), Phoenix Motorcars (Ford F450/F59 chassis	Non-emergency buses.
BUS - 40 OR MORE PASSENGERS	22	1	BYD, ENC, Gillig, New Flyer, NOVA, MCI, Proterra	Non-emergency buses.
BUS - ELECTRIC	3	1	Blue Bird (Type C&D), BYD, IC Bus (Type C), Lion, Thomas Built (Type C w/ Proterra system)	These are the initial EV school buses.
BUS - UNDER 24 PASSENGERS	15	1	Ford F-450 chassis based EV school buses by Collins Corporation; Lion M	Non-emergency buses.
COLLECTION TRUCK - 16 YD	55	1	Mack LR Electric, BYD 8R, Lion8	Parks. Non-plow.
COLLECTION TRUCK - 20 YD	18	1	Mack LR Electric, BYD 8R, Lion8	DOT. Non-plow.
COLLECTION TRUCK - 25 YD	2	1	Mack LR Electric, BYD 8R, Lion8	Parks. Non-plow.
COLLECTION TRUCK - 6 YD	62	1	Mack LR Electric, BYD 8R, Lion8	Parks. Non-plow.
CROSSOVER	621	1	GM Bolt	Currently All-Electric
NYPD SEDAN	3,236	1	Ford Mach E, Tesla	NYC introducing first 200+ Mach Es in 2022 for law enforcement.
SEDAN	3,307	1	GM Bolt, Nissan Leaf, Other	DSNY. Use in emergency snow operations must be proven. Charging capacity

Type	Count	Tier	BEV Models	DCAS Notes
				for emergencies must be established.
SWEEPER	474	1	Global Class 7 BEV	DSNY currently operates initial BEV unit. PHEV is also an option.
VAN - ADA ACCESSIBLE	13	1	Ford EV Transit, Passenger	
VAN - PASSENGER	696	1	Ford EV Transit, Passenger	
VAN - STEP	13	1	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
VAN - UTILITY	1,163	1	Ford EV Transit	DCAS launching first order of 300+ EV cargo vans.
HYDRANT REPAIR TRUCK	8	1	Ford F-150 Lightning	
MOBILE OFFICE	3	1	BYD, ENC, Gillig, New Flyer, NOVA, MCI, Proterra	
COLLECTION TRUCK - ALLEY 10 YD	21	1	Mack LR Electric, BYD 8R, Lion8	This would refer to collection trucks not being used for plowing.
COLLECTION TRUCK - ALLEY 20 YD	36	1	Mack LR Electric, BYD 8R, Lion8	This would refer to collection trucks not being used for plowing.
PICKUP - FORD F150	267	1	Ford F-150 Lightning	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates.
PICKUP - FORD RANGER	61	1	Ford Maverick EV. Ford Lightning.	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates.
PICKUP - GMC SIERRA	8	1	Ford F-150 Lightning	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting,

Type	Count	Tier	BEV Models	DCAS Notes
				water tanks, sprayers, and automated life gates.
PICKUP - TOYOTA TACOMA	1	1	Toyota Tacoma Electric	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates.
BOX TRUCK	41	1	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	

A.2 On-Road Tier 2 Standard Types

Type	Count	Tier	BEV Models	DCAS Notes
FUEL TRUCK PICKUP	11	2	Ford Lightning.	Fuel truck is tank within bed of pickup. Safety and regulatory issues must be addressed.
NYPD MOTORCYCLE	129	2	Livewire, Energica	Questions about range. Needs further development and testing.
PICKUP W VACUUM SWEEPER	3	2	Ford F-150 Lightning	Sweeper unit may not be electric at this time even if pickup is.
BOOM TRUCK	13	2	Zeus Electric Chassis; Bollinger Work Truck Chassis	Operational viability of models needs to be proven.
FIRE PERSONNEL CARRIER - PICKUP	161	2	Ford EV Transit Passenger	Vehicle could be available sooner but FDNY application needs to be proven.
AMBULANCE	604	2	Demers eFX	NYC implementing PHEV ambulances now through APU units. Operations of charging must be established.
COLLECTION TRUCK - FRONT LOAD	94	2	Mack LR Electric, BYD 8R, Lion8	This would refer to collection trucks not being used for plowing.
CORRECTION BUS	122	2	Blue Bird (Type C&D), BYD, IC Bus (Type C), Lion, Thomas Built (Type C w/ Proterra system)	NYC ordering initial 3 busses for initial Correction use now. Operation in emergency correction capacity must be proven.
MINIVAN	205	2	Pacifica EV	DCAS implementing PHEV Mini-vans currently.
NYPD PASSENGER VAN	1,025	2	Ford EV Transit Passenger	Police vans have greater functional requirements than non-police passenger vans.
NYPD SUV	2,829	2	Ford Excursion EV	NYPD SUVs have a particular use and duty cycle that will need to be established and tested. Vehicles may be in market in under 3 years but proving for NYPD use will take longer. NYPD may investigate PHEV models.
SUV	1,534	2	Ford Excursion EV	Non-emergency. DSNY units may be PHEV to support winter emergency operations.
VAN - COMMAND POST	22	2	Bollinger Deliver-E, Mercedes Benz e-Sprinter	NYPD Will Test E-Transit model

Type	Count	Tier	BEV Models	DCAS Notes
VAN - OTHER	20	2	Bollinger Deliver-E, Mercedes Benz e-Sprinter	
PICKUP - CHEVROLET COLORADO	18	2	Ford Maverick EV	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates.
PICKUP - CHEVROLET SILVERADO	204	2	Chevrolet Silverado EV	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates.
PICKUP - CHEVROLET SILVERADO HYBRID	15	2	Chevrolet Silverado EV	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates.
PICKUP - DODGE RAM 1500	2	2	RAM 1500 EV	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates.
PICKUP - DODGE RAM 2500	96	2	Ford F series Lightning	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates. As per NYPD Ford F series lightning 150 is the only available model for now
PICKUP - FORD F250 AND HYBRID F250	908	2	Ford F series Lightning	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates. As per NYPD Ford F series lightning 150 is the only available model for now

Type	Count	Tier	BEV Models	DCAS Notes
PICKUP - FORD F350	288	2	Ford F series Lightning	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates. As per NYPD Ford F series lightning 150 is the only available model for now
PICKUP - FORD F450	11	2	Ford F series Lightning	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates. As per NYPD Ford F series lightning 150 is the only available model for now
PICKUP - FORD F550	11	2	Ford F series Lightning	Pickups are needed in single and crew cab and must be able to support a wide variety of support equipment and functions including plowing, salting, water tanks, sprayers, and automated life gates. As per NYPD Ford F series lightning 150 is the only available model for now
AERIAL LIFT - PLATFORM TRUCK	17	2	Zeus Electric Chassis; Bollinger Work Truck Chassis	Electric bucket truck operations must be proven.
AERIAL/BUCKET LIFT TRUCK	167	2	Zeus Electric Chassis; Bollinger Work Truck Chassis	Electric bucket truck operations must be proven.
AERIAL/ BUCKET LIFT VAN	6	2		Electric bucket truck operations must be proven.
ATTENUATOR TRUCK	161	2	Zeus Electric Chassis; Bollinger Work Truck Chassis	DOT
BEACH WAGON	19	2	Ford F-150 Lightning	Electric truck operations on sand must be proven.
CABLE TRUCK	3	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	

Type	Count	Tier	BEV Models	DCAS Notes
CATCH BASIN MACHINE TRUCK	51	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	DEP
COMPRESSOR TRUCK	3	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
CONTAINER TRUCK	110	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
CRANE MOUNTED TRUCK	10	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
DUMP TRUCK - 15+ YD	167	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
DUMP TRUCK - 3 TO 4 YD	3	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
DUMP TRUCK - 4 YD	2	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
DUMP TRUCK - 5 - 10 YD	28	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV,	

Type	Count	Tier	BEV Models	DCAS Notes
			International eMV, Lion6	
DUMP TRUCK - UNDER 5 YD	330	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
GRAFFITI TRUCK	9	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
MOBILE LAB	4	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
MOBILE SHREDDER	4	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
HEALTH CENTER - MOBILE	4	2	BYD, ENC, Gillig, New Flyer, NOVA, MCI, Proterra	
LIGHT CONSTRUCTION TRUCK	56	2	Ford F series Lightning	
MOBILE TRAINING VEHICLE	3	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
RACK TRUCK	267	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	

Type	Count	Tier	BEV Models	DCAS Notes
REFRIGERATED - TRUCK	17	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
REGULATOR TRUCK	31	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
SPRAYER TRUCK	6	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
TIRE TRUCK	9	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
REFRIGERATED - VAN	16	2	Ford F-450 chassis based EV	
TRACTOR TRAILER TRUCK	130	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
TRUCK - MISC	39	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
TRUCK - OTHER	20	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	

Type	Count	Tier	BEV Models	DCAS Notes
TRUCK - UTILITY HAULSTER	141	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
UTILITY TRUCK	240	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
UTILITY TRUCK W LIFT	20	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
WATER TRUCK	16	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
WELDING TRUCK	41	2	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	

A.3 On-Road Tier 3 Standard Types

Type	Count	Tier	BEV Models	DCAS Notes
ARMORED TRUCK	2	3	Zeus Electric Chassis; Bollinger Work Truck Chassis	Emergency
SALT SPREADER TRUCK	428	3	Ford F-150 chassis based EVs	DSNY. Use in emergency snow operations must be proven. Charging capacity for emergencies must be established. If this category is in reference to an 8YD or 16YD Salt Spreader the Ford F-150 is not a feasible solution. DSNY is currently utilizing a Mack MR Chassis with a GVWR of 49,000LBS for a 8YD and 72,000LBS for a 16YD. A specialized solution would need to be developed by the Manufacturers and tested by DSNY.
DUAL SALT SPREADER DUMP	88	3	F-150 chassis based EVs	DSNY. Use in emergency snow operations must be proven. Charging capacity for emergencies must be established. It will not be suitable to use the EV Based Ford F150 as the chassis for a Dual Rear Axle Configuration Haulster Salt Spreader. The EV F-150 has a GVWR of 8,250LBS. The chassis currently used by DSNY for this configuration is a Ford F-550 Chassis with a GVWR of 19,500. DSNY will have to continue this chassis until an equal or greater EV Chassis is available.
FIRE - RESCUE TRUCK	18	3	Zeus Electric Chassis; Bollinger Work Truck Chassis	Capacity to handle FDNY specialzed operations needs to be established
FIRE - SATELLITE TRUCK	6	3	Zeus Electric Chassis; Bollinger Work Truck Chassis	Capacity to handle FDNY specialzed operations needs to be established
FIRE - SUPPORT TRUCK	7	3	Zeus Electric Chassis; Bollinger Work Truck Chassis	Capacity to handle FDNY specialzed operations needs to be established
HAZMAT TRUCK	41	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	

Type	Count	Tier	BEV Models	DCAS Notes
HAZMAT VEHICLE	15	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
MOBILE RESP VEHICLE, NYPD	124	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
COMMAND POST TRUCK	34	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Needs testing and must be proven. NYPD also looking to implement trailer command posts to limit need for trucks.
FORESTRY - CHIPPER DUMP TRUCK	39	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Very specialized units for Parks Department that will need to be duty tested
FORESTRY - TREE TRIMMER TRUCK	51	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Very specialized units for Parks Department that will need to be duty tested
DSNY COLLECTION TRUCK	2,010	3	Mack	Electric Unit for Collection Services is available now. Electric units for plow operations must be developed and are not currently available. Charging and backup power infrastructure to support emergency operations must be in place. NYC will also be assessing potential for a plug in hybrid version.
FIRE BRUSH UNIT	7	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Electric Vehicle Options exist but fire fighting capacity would have to be proven.
DEP SPECIALIZED TRUCK	34	3	Kenworth K270E/370E, BYD	Capacity to handle DEP specialzed operations needs to be proven.

Type	Count	Tier	BEV Models	DCAS Notes
			5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
FORESTRY - LOG LOADER	14	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
JET RODDER - MECHANIC	9	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
JET RODDER TRUCK	43	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
LOAD LUGGER	13	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
POST DRIVER EXTRACTOR TRUCK	7	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
SEWER TRUCK	5	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
STREET FLUSHER	20	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	

Type	Count	Tier	BEV Models	DCAS Notes
THAW TRUCK	5	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
TOW TRUCK - FLAT BED	31	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Needs testing and must be proven. NYPD performs out of state tow which may be a range issue
TOW TRUCK - WRECKER	302	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
VACUUM TRUCK	6	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
FUEL TRUCK	56	3	Zeus Electric Chassis; Bollinger Work Truck Chassis	NYC will look to implement electric battery storage alternatives to emergency liquid fuel storage trucks.
VAN - NYPD SPECIALIZED	10	3	Mercedes Benz eSprinter	Specialized policing purposes
CONCRETE MIXER TRUCK	8	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	Highly specialized unit. This will be very challenging to implement as electric.
DUMP TRUCK - SNOW PLOW	6	3	Kenworth K270E/370E, BYD 5F/6F/T7, Peterbilt 220EV, International eMV, Lion6	
FIRE LADDER TRUCK	187	3	Pierce Volterra, E-ONE Vector, Rosenbauer	While there are a few possible electric versions in the market today, these must be proven for real world NYC fire fighting situatons. FDNY also currently fuels most of these trucks in the fiire houses using

Type	Count	Tier	BEV Models	DCAS Notes
				small liquid fuel tanks. Emergency charging infrastructure and backup power must be established.
FIRE PUMPER TRUCK	250	3	Pierce Volterra, E-ONE Vector, Rosenbauer	While there are a few possible electric versions in the market today, these must be proven for real world NYC fire fighting situatons. FDNY also currently fuels most of these trucks in the fiire houses using small liquid fuel tanks. Emergency charging infrastructure and backup power must be established.

A.4 Off-Road Tier I Standard Types

Type	Count	Tier	BEV Models	DCAS Notes
AERIAL LIFT - OFF ROAD BOOM	24	1	JLG Aerial/Boom lift	
AERIAL LIFT - PLATFORM LIFT	4	1	JLG Aerial/Boom lift	
COMPACT TRACK LOADER	7	1	Bobcat T7X Compact Track Loader	
COMPRESSOR - TRAILER	101	1	Atlas	
LIGHT TOWER - SOLAR	109	1	Progress Solar, Wanco	These are solar units now.
MESSAGE BOARD - TRAILER	218	1		These are solar units now.
MOWER - RIDE ON	175	1	Ryobi 54" Electric Riding Lawn Mower	
SNOWMOBILE	6	1	Taiga	Range can be limiter.
SWEEPER	2	1	Madvac	Sweepers for use inside buildings.
TRAM/TROLLEY	4	1	Moto Electric, GEM, Speciality Vehicles	
UTILITY CART	31	1	GEM, Gator.	DCAS operates electric units now. Plow capacity is a limiter.
ICE RESURFACER	1	1	Zamboni	
VACUUM LEAF TRUCK	3	1	Madvac	Parks implementing first electric version now.

A.5 Off-Road Tier 2 Standard Types

Type	Count	Tier	BEV Models	DCAS Notes
ATV	42	2	Polaris, DRR	Battery range can be a limiter.
FORKLIFT	631	2	Yale Four Wheel Electric Forklift Series, Toyota Electric Forklift Series	Electric forklifts are in operation now. Load capacity is a limiter.
LIGHT TOWER	558	2		DCAS implements solar-electric light towers now. Assignments in shaded areas is a limiter.
NYPD SMART CAR	152	2	Smart EQ, GM Bolt	NYPD assessing transition to Bolts. These are currently listed as off-road tied to historic use.
OFF ROAD UTILITY VEHICLE	704	2	GEM, Polaris Ranger EV, John Deere TE 4x2 Electric	EV in operation today. Plowing and 4x4 are limiters to electric models.
SCOOTER/MOPED	290	2	Piaggio 1, Westward Max EV 3	Must be proven for policing operations.
BALLFIELD RAKE	21	2		Equipment is similar to ride on mowers.
BEACH TRACTOR	31	2	Moarch MK-V, Solectrac e25 Compact Electric Tractor	
REFRIGERATED - TRAILER	29	2		Only refrigeration unit requires power source.
TRACTOR	246	2	Moarch MK-V, Solectrac e25 Compact Electric Tractor	
CRANE	21	2		There are multiple current electric crane suppliers.
SKID STEER / UTILITY WORK MACHINE	240	2	Bobcat	
WHEEL LOADER	26	2	Volvo	

A.6 Off-Road Tier 3 Standard Types

Type	Count	Tier	BEV Models	DCAS Notes
AMBULANCE - OFF ROAD	15	3	John Deere Gator	Gator type units. There are existing electric models. Must be proven for emergency application.
TRAILER - HIGH PRESS JET RODDER	3	3		Highly specialized trailer unit. This will be very challenging to implement as electric.
FIRE BRUSH UNIT	1	3		Fire emergency unit.
TOW TRUCK - TUG PUSHER	5	3		Very low mileage but heavy power requirements. For towing within compounds.
ASPHALT HEATER - TRAILER	87	3		DOT specialized equipment.
ASPHALT PAVER	26	3		DOT specialized equipment.
BACKHOE	44	3	Case 580 EV Electric Backhoe (compact construction vehicle)	
BARRIER TRANSFER MACHINE	3	3		Highly specialized unit. This will be very challenging to implement as electric.
BASKET LOADER	4	3		Highly specialized unit. This will be very challenging to implement as electric.
BEACH CLEANER	3	3		Highly specialized unit. This will be very challenging to implement as electric.
BULLDOZER	5	3		Highly specialized unit. This will be very challenging to implement as electric.
CHIPPER - TRAILER	61	3		Parks. Highly specialized unit. Energy intensive. This will be very challenging to implement as electric.
CRUSHER	2	3		Highly specialized unit. This will be very challenging to implement as electric.
EXCAVATOR	7	3		Highly specialized unit. This will be very challenging to implement as electric.
FORESTRY - STUMP CUTTER	17	3		Highly specialized unit. This will be very challenging to implement as electric.

Type	Count	Tier	BEV Models	DCAS Notes
FRONT END LOADER	368	3		Volvo is currently developing an “L25” BEV Front End Loader. This is a smaller size front end loader, 1.2CY. It may be possible for Volvo to develop larger models as the technology progresses.
HYDRAULIC EXCAVATOR	14	3		Highly specialized unit. This will be very challenging to implement as electric.
LANDFILL CRAWLER	6	3		Highly specialized unit. This will be very challenging to implement as electric.
LANDFILL OFF ROAD DUMP	2	3		Highly specialized unit. This will be very challenging to implement as electric.
MILLER PLANER	16	3		DOT specialized equipment.
ROLLER	47	3		DOT specialized equipment.
SNOW MELTER	31	3		DSNY. Highly specialized unit. Energy intensive. This will be very challenging to implement as electric.
TAR KETTLE TRAILER	51	3		DOT specialized equipment.
TRAILER - PRESSURE WASHER	2	3		Parks specialized equipment.
TUB GRINDER	2	3		Highly specialized unit. Energy intensive. This will be very challenging to implement as electric.

A.7 Off-Road Standard Types for which Tiers Designation Is Not Applicable

Type	Count	DCAS Notes
CONCRETE/CEMENT MIXER - TRAILER	27	
EMERGENCY DIESEL GENERATOR - TRAILER	103	Diesel Back Up Generators may remain in place. DCAS will look for battery storage alternatives.
TRAILER - CARGO/UTILITY	19	No fuel
TRAILER	244	No fuel
COMMAND POST TRAILER	6	No fuel
MOBILE COMMAND SHELTER	3	No fuel
PRESSURE WASHER - TRAILER	2	No fuel
SURF/TURF RAKE	26	No fuel
TRAILER - HORSE	32	No fuel
TRAILER - JET SKI	8	No fuel
TRAILER - LIVE BOTTOM	10	No fuel
TRAILER - LOAD BANK	1	No fuel
TRAILER - REEL	9	No fuel
TRAILER - ROCK WALL	1	No fuel
TRAILER - STAGE	6	No fuel
ATTENUATOR - TRAILER	4	No fuel
MOBILE OFFICE	3	No fuel
FLATBED TRAILER	2	No fuel
FUEL TRAILER	2	Fuel trailer carries but does not use fuel itself. Part of emergency fuel operations.

Appendix B: Resources and References

- https://globaldrivetozero.org/tools/zero-emission-technology-inventory/
- https://marc-gallet.fr/publication/2018-estimation-of-the-energy-demand-of-electric-buses-based-on-real-world-data-for-large-scale-public-transport-networks/Gallet_et_al_2018-Estimation-of-the-energy-demand-of-electric-buses-based-on-real-world-data-for-large-scale-public-transport-networks.pdf
- https://www.michigan.gov/msp/divisions/training/precision-driving-unit/police-vehicle-test-results
- https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/harnessing-momentum-for-electrification-in-heavy-machinery-and-equipment
- https://www.caranddriver.com/news/g29994375/future-electric-cars-trucks/
- https://www.energy.gov/sites/default/files/2021-06/elt198_johnson_2021_o_5-11_558pm_LR_TM.pdf
- https://csrc.nist.gov/csrc/media/projects/supply-chain-risk-management/documents/ssca/2017-spring/brendan_harris_day2_am2.pdf

U.S. Department of Transportation
John A. Volpe National Transportation Systems Center
55 Broadway
Cambridge, MA 02142-1093

617-494-2000
www.volpe.dot.gov

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