The City of New York
Department of Sanitation

2020 Annual Report on Alternative Fuel Vehicle Programs
Pursuant to Local Law 38 of 2005

NYC's First Battery-Electric Mechanical Broom

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DSNY Annual Report on Alternative Fuel Vehicle Programs

I. Introduction

The Department of Sanitation (DSNY) operates a sizeable fleet of trucks and other vehicles to carry out its mission to keep New York City healthy, safe and clean by collecting, recycling and disposing of waste, cleaning streets and vacant lots, and clearing snow and ice. In 2005, the City Council enacted Local Law 38 (LL38/2005), which directs DSNY to report annually on its use and testing of alternative fuel vehicles.[1] This report, which is submitted to the Mayor, the Comptroller and the City Council in accordance with LL38/2005, discusses the testing, analyses and assessments of DSNY's alternative fuel sanitation collection vehicles and street sweepers, and the feasibility of incorporating new alternative fuel sanitation vehicles and technology into DSNY's fleet.[2]

Highlights for the 2020 Report

- DSNY's fleet of 5,955 heavy duty and light duty vehicles has 811 vehicles that operate on various alternative fuels (14%), including electric, hybrid-electric and natural gas.
- DSNY has begun pilot-testing its first Battery-Electric Collection Truck.
- DSNY has begun pilot-testing its first Battery-Electric Mechanical Broom.
- DSNY took delivery of 6 new Mack collection trucks with a new type of compressed natural gas engine.
- DSNY is now testing 12 trucks with "stop-start" ultra-capacitor technology to reduce emissions by shutting off the engine when idle, reducing fuel use and emissions by up to 30%.
- DSNY was one of six recipients of the prestigious CALSTART Blue Sky Award, presented to companies, organizations or individuals making outstanding contributions to clean air, climate change, and the clean transportation tech industry.
- In 2020, DSNY collection truck fleet traveled 12,045,992 vehicle miles, mechanical brooms traveled 1,178,904 miles.
- Diesel collection trucks and mechanical brooms comprise most of the heavy-duty fleet and use Ultra Low Sulfur Diesel fuel with 5% to 20% biofuels from soybeans.
- Collection Trucks: 2,298 diesel, 39 natural gas, 46 hybrid-hydraulic, and 1 electric.
- Mechanical Brooms: 427 diesel, 27 hybrid-electric, and 1 electric.
- Light Duty Fleet: 18 battery-electric, 520 gas-electric hybrids, 131 plug-in hybrid–electric, 394 gasoline, and 208 diesel.
- In FY2020, DSNY's fleet consumed approximately 8.1 million gallons of B5 to B20 biodiesel fuel, and 600,000 gallons of gasoline, with a 10% ethanol component made from corn.
- With state-of-the-art controls, DSNY diesel emissions of particulate matter (PM) and nitrogen oxides (NOx) are 95% lower per truck than in 2005.

[1] NYC Administrative Code § 24-163.2(c)(1) & (2).

[2] DSNY's mandated pilot program that used alternative fuel street sweeping vehicles in four sanitation districts with one district in an area with high rates of asthma among residents has been reviewed in prior reports.

- DSNY diesel fuel use declined by 14% in FY2020 compared to FY2019, due to improved fuel efficiency and shorter routes to dump refuse at DSNY's new Marine Transfer Stations built under the City's Solid Waste Management Plan.
- DSNY gasoline use in FY2020 has declined by 48% compared to FY2005, due to improved gas mileage and use of hybrid-electric and battery-electric vehicles.

DSNY endeavors to operate the cleanest possible fleet and therefore seeks to minimize emissions of concern from such operations, notably particulate matter (PM), nitrogen oxides (NOx), and greenhouse gases (GHGs) such as carbon dioxide.[3] As of January 2021, DSNY's active fleet of 5,955 vehicles includes 2,298 collection trucks, 427 street sweepers, 431 salt/sand spreaders, 450 front-end loaders, 1,271 light-duty vehicles and 1,078 various other support vehicles. Based on Fiscal Year 2020 figures, DSNY's diesel fleet used approximately 8.1 million gallons of diesel fuel. As discussed below, thanks to new technologies DSNY has achieved great success in minimizing emissions of PM and NOx from its fleet. DSNY strives to operate the cleanest big city fleet and in 2013 won the prestigious federal USEPA "Breathe Easy Leadership Award." DSNY was nominated for the 2019 ACT Expo Fleet Award recognizing government fleets that have shown true leadership deploying alternative fuel vehicles and achieve sustainability in fleet operations. In 2020, DSNY was one of six recipients of the prestigious CALSTART Blue Sky Award, which is presented to companies, organizations or individuals making outstanding contributions to clean air, climate change, and the clean transportation technologies industry. The Blue Sky Award recognized DSNY's leadership and innovation in sustainable transportation technologies and solutions. Since LL 38/2005 was passed, DSNY's heavy-duty truck fleet relies mostly on clean diesel technology and ultra-low sulfur fuel while the Department's light-duty fleet increasingly incorporates hybrid-electric, plug-in hybrid-electric and all-electric technology to minimize vehicular emissions.

This report includes the total number of alternative fuel "sanitation vehicles" owned or operated by DSNY by type of alternative fuel used, discusses notable advances in DSNY's clean diesel fleet, and provides information regarding DSNY efforts to further incorporate alternative fuel vehicles into its fleet to further reduce emissions, including GHGs, in accordance with City air quality and sustainability goals. "Sanitation vehicles" are defined by LL38/2005 as vehicles used by DSNY "for street cleaning purposes or for the collection of solid waste or recyclable materials."[4]

II. Air Quality

New York City's air quality has improved and since 2013 met federal standards for fine particulate matter ($PM_{2.5}$), but it remains out of compliance with standards for ozone. The ozone

[3] While not known to cause asthma, PM, especially fine PM 2.5 microns in diameter or smaller ($PM_{2.5}$) is associated with increased respiratory symptoms, while NOx can be a precursor in the formation of ground-level ozone (regional smog) which is associated with exacerbation of asthma-related symptoms. *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*, 66 Federal Register at 5012 (Jan. 18, 2001); "Public Health" chapter in *New York City Comprehensive Solid Waste Management Plan Final Environmental Impact Statement* (April 2005).

[4] NYC Administrative Code § 24-163.2(a)(6).

levels for the City's counties have been trending downward since the 2005-2007 period. The USEPA proposed a new, more restrictive annual standard for $PM_{2.5}$ in June 2012, which took effect in December 2012. USEPA reduced the new annual standard from 15 micrograms per cubic meter to 12 micrograms per cubic meter. Based on 2017-2019 measurements, New York City's air meets the new 2012 standard.[5] In 2010, USEPA set a new 1-hour NO_2 standard of 100 parts per billion (ppb). The form for the 1-hour NO_2 standard is the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations. The City complies with this NO_2 standard. In October 2015, USEPA strengthened the annual standard for ozone. USEPA reduced the 8-hour primary standard for ozone from 0.075 parts per million (ppm) to 0.070 ppm, averaged over three years. New York City, like the surrounding counties in the metropolitan area, does not meet this standard based on 2017-2019 data.

III. Continuing Improvements in DSNY's Fleet Emissions

DSNY's fleet is achieving greater than *95% reduction in PM and 95% reduction in NOx emissions* fleet-wide compared with DSNY's heavy duty diesel fleet in 2005, while the newest trucks achieve *98% reductions* in each pollutant as compared with pre-1988 diesel engines. In addition, since 2005 DSNY's fleet has cut annual diesel fuel use by 22% (8,154,134 gallons of B5 and B20 biodiesel consumed in FY2020) and cut its light duty fleet gasoline use by 48% (599,942 gallons consumed in FY2020).

A. ULSD Fuel, New Vehicle Standards, Diesel Particulate Filters, and Retrofits

Currently all the Department's light, medium and heavy-duty diesel vehicles utilize the industry's latest computer-controlled and regulated clean-diesel engines for their respective engine model years (MY). DSNY's Clean Fleet Program of testing and development of state-of-the-art technology and alternative fuels helped pioneer the improvements in heavy duty diesel emissions that the federal government subsequently mandated nationwide for the 2007 MY and later. DSNY's Program includes obtaining research grants, partnering with industry to test vehicles under real world conditions, and operating a vehicle testing facility for heavy duty trucks. DSNY's state-of-the-art heavy-duty Vehicles Testing Laboratory, one of only two east of the Mississippi, conducts research and development projects, and performs independent exhaust emissions testing of various emission control technologies, alternative fuels and novel diesel fuel blends.

- The Department pioneered the use of ultra-low sulfur diesel fuel (ULSD)—limited to 15 ppm of sulfur—in July of 2001 in certain districts and expanded its use to its entire fleet in 2004 in advance of the USEPA June 2006 nationwide ULSD mandate. The new standard represents a *reduction of 97%* from the previous low sulfur standard for on-road diesel fuel of 500 ppm that took effect in 1993. Prior to 1993, the average sulfur content for on-road diesel fuel was 2500 ppm.

- ULSD allowed DSNY to expand its use of various advanced emission-control after-treatment technologies, such as diesel particulate filters and diesel oxidation catalysts. Previously, higher sulfur content fuel would have clogged these devices. These controls reduce

[5] The annual PM2.5 NAAQS is the 3-year average annual mean concentration.

particulate matter by 90% or better, as verified in DSNY testing.

- Since mid-2006, all of DSNY's new diesel truck purchases have met the stringent 2007 USEPA new-truck standards limiting particulate matter to 0.01 grams per brake horsepower-hour (g/bhp-hr), *a reduction of 90% from the 2006 MY limit of 0.1 g/bhp-hr*.[6] As of the 2010 MY NOx is limited to 0.2 g/bhp-hr, compared to 2.0 g/bhp-hr in the 2006 MY and 4.0 g/bhp-hr in the 2003 MY. NOx emission reductions are achieved mainly by diesel exhaust after-treatment technology called selective catalytic reduction (SCR). SCR technology utilizes diesel exhaust fluid (urea) to treat the exhaust and remove the NOx.

- To address the legacy of emissions from older trucks, DSNY mechanics have installed Best Available Retrofit Technology (BART) devices such as particulate filters on pre-2007 trucks, as mandated by Local Law 73 of 2013 (LL 73/2013). These devices achieve reductions of up to 90% in PM and up to 25% in NOx. By January 1, 2017 at least 90% of DSNY's diesel-powered on-road fleet were required to utilize a diesel particulate filter or be equipped with an engine that meets USEPA 2007 PM standards. DSNY exceeded this target. Including both factory-installed equipment and retrofits, as of January 1, 2021 more than 99% of DSNY's on-road diesel fleet was so equipped.

B. Greenhouse Gas Emissions

GHG emissions from human activities cause climate change and global warming. Motor vehicles fueled by diesel and gasoline represent the largest single source of U.S. net GHG emissions.[7] To help reduce such emissions, the USEPA and the National Highway Traffic Safety Administration jointly developed a GHG emissions program and fuel efficiency standards applicable to all heavy- and medium-duty vehicles.[8] The GHG/fuel economy standards were adopted in two phases. Under the Phase 1 and Phase 2 regulations, different CO_2 and fuel consumption standards are applicable to different categories of vehicles, including combination tractors, trailers, vocational vehicles, and heavy-duty pickups and vans. Phase 1 regulations, adopted in 2011, require vocational vehicles (such as DSNY collection trucks) to achieve up to a 10% reduction in fuel consumption and CO_2 emissions by 2017 MY over the 2010 baselines. Phase 2 regulations, published in 2016, apply to MY 2021-2027 vehicles.

In FY2020, DSNY ordered 305 new collection trucks and expects to receive delivery in CY 2021; these new trucks will comply with EPA Phase-1 GHG standards, adding to the 446 Phase-1 GHG-compliant collection trucks acquired previously. The new reduced-GHG trucks will aid DSNY in making progress toward NYC's *OneNYC* GHG reduction goals of net-zero GHG emissions citywide by 2050.[9]

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[6] 66 Fed. Reg 5001, 5005 (Jan. 18, 2001). By comparison, the 1990 federal standard for particulate matter for heavy duty diesel highway engines was 0.60 g/bhp-hr. NOx standards have been reduced over time from 10.7 g/bhp-hr in 1988 to 0.2 g/bhp-hr starting in 2007, with a phase-in allowed until 2010, yielding an effective limit of 1.2 g/bhp-hr for 2007-2009 MYs.

[7] USEPA's Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2018. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

[8] The standards are applicable to all on-road vehicles rated at a gross vehicle weight ≥8,500 lbs, and the engines that power them.

[9] *OneNYC 2050: Building a Strong and Fair City*; A Livable Climate, Volume 7 of 9; nyc.gov/OneNYC.

IV. Alternative Fuel Vehicles

Despite the success of DSNY's Clean Diesel Program in minimizing PM and NOx fleet emissions, further improvements are possible as technology advances. DSNY therefore continues an active program of testing other kinds of fuels and technologies. Under LL38/2005, "alternative fuels" include natural gas, liquefied petroleum gas, hydrogen, electricity, and any other fuel which is at least eighty-five percent, singly or in combination, methanol, ethanol, any other alcohol or ether. Including collection trucks, sweepers, and light duty vehicles that are not used to collect refuse or recyclables, DSNY currently has 811 vehicles that operate on various alternative fuels, including electric and hybrid-electric vehicles.

In December 2015, Mayor de Blasio announced the launch of NYC Clean Fleet, a comprehensive plan which will: (1) add 2,000 electric vehicles (EVs) to its municipal vehicle fleet by 2025, which would give New York City the largest EV fleet in the country; and (2) achieve a 50% reduction in GHG emissions from fleet operations below 2005 levels by 2025, and an 80% reduction by 2035. DSNY is adapting its fleet to this important initiative.

In February 2020, Mayor de Blasio issued Executive Order 53, with the goal of New York City achieving an all-electric, carbon-neutral fleet by the year 2040. DSNY is exploring options for fleet compliance with this goal, including testing a battery-electric collection truck and a battery-electric mechanical broom street sweeper, as discussed below.

A. Light-Duty Vehicles

DSNY's light duty fleet currently includes 669 advanced low- or zero-emission vehicles, such as hybrid-electric, plug-in hybrid-electric, and battery-electric vehicles (BEVs). Hybrid-electric vehicles operate on gasoline assisted by battery technology. Plug-in hybrid-electric vehicles can operate in battery mode for a certain distance before the gasoline engine must be used. BEVs operate on electric battery power alone. Consistent with LL38/2005 and NYC Clean Fleet, DSNY expects to increase its fleet of light-duty electric and hybrid-electric vehicles. However, due to the City's budget crisis caused by the Covid-19 pandemic, DSNY purchased no alternative-fuel light duty vehicles for delivery in FY2021.

1. Hybrid-Electric Vehicles

DSNY currently owns and operates 520 hybrid-electric vehicles. These include Ford Fusion[10] and Escape, Toyota Prius and RAV4. In FY2019, DSNY ordered 70 additional Toyota RAV4 hybrid-electric 4-wheel drive vehicles replacing 70 older gasoline SUVs that have reached the end of their useful life. The 2019 RAV4's have an EPA rating of 41 mpg (combined) and benefit DSNY by increasing the SUV fleet average fuel economy. DSNY did not purchase any hybrid-electric light duty vehicles in FY2020.

[10] EPA mileage estimates for the Fusion Hybrid MY2014 are 41 mpg highway and 44 mpg city.

2. Plug-In Hybrid-Electric Vehicles

DSNY's fleet includes 131 plug-in hybrid–electric vehicles: 14 Chevrolet Volt sedans, 82 Ford Fusion Energi Plug-in Hybrids, and 35 Mitsubishi Outlander Plug-in SUVs (4-wheel drive, delivered in FY2020). The Chevrolet Volt sedans can run on battery power for up to 40 miles before a gasoline engine starts up to charge the battery,[11] while the battery range is 19 miles for Ford Fusion Energi Plug-in Hybrids and 22 miles for the Mitsubishi Outlander Plug-in Hybrid SUVs.

3. Discussion: Plug-in Hybrid vs. Conventional Hybrid

The Ford Fusion Energi Plug-in Hybrid, Chevrolet Volt and Mitsubishi Outlander Plug-in Hybrid have the same California Air Resources Board (CARB) emissions rating (Alternate Technology Partial Zero Emission Vehicle, or AT-PZEV) as the (non-plug-in) Toyota Prius and Toyota RAV4 hybrids. As such, the Fusion Energi Plug-in Hybrid, the Volt, the Outlander and the Prius are capable of zero emissions when running only on battery power, but the Toyota Prius and RAV4 battery-only range is rated by the USEPA at under one mile. As a DSNY sedan shift averages 33 miles of driving, a Toyota Prius and RAV4 will utilize its internal combustion engine for almost the entire shift and have higher direct emissions than a Fusion Energi Plug-in Hybrid or Volt or Outlander, which have longer battery-mode ranges. The Fusion Energi Plug-in Hybrids in DSNY's current fleet will utilize their battery for approximately 19 miles and will use their internal combustion engine for the remaining 14 miles of the DSNY shift route. The Volt will operate in electric mode for the entire 33-mile shift. The Mitsubishi Outlander will operate in electric mode for approximately 22 miles and will use its internal combustion engine for the shift's remaining 11 miles.

The plug-in hybrids have performed well in the field. The advantage of the plug-in hybrid over a conventional hybrid is its ability to run on battery mode for an extended range, therefore emitting fewer direct air pollutant and GHG emissions during a typical duty cycle than a conventional hybrid. For example, according to the USEPA, a 2015 Fusion Energi Plug-in Hybrid gets the equivalent of 88 miles per gallon when operating in battery mode (MPGe), and 38 mpg when operating in gasoline mode. The USEPA rated the 2017 Volt for 53 miles of battery range and 106 MPGe in battery mode. The USEPA rated the 2019 Mitsubishi Outlander for 74 MPGe when operating in battery mode and 25 miles per gallon when operating in gasoline mode. The USEPA rated the 2017 Prius for 52 mpg combined/54 mpg City/50 mpg highway. The USEPA rated the 2019 RAV4 for 41 mpg combined/38 mpg City/40 mpg highway. In addition to the emission benefits, costs to be considered include fuel, depreciation and maintenance. As the City self-insures, any differential cost in insurance rates for these vehicles is not relevant.

In Fiscal Year 2019, the purchase price available to the City varied by hybrid model, with plug-ins more expensive than conventional hybrids: Mitsubishi Outlander Plug-in 4x4 SUV ($36,700), Ford Fusion Energi Plug-in Hybrid ($36,091), Chevrolet Volt Plug-in ($35,369), Toyota Prius Prime Plug-in ($24,994), Toyota RAV4 4x4 Hybrid ($27,256), and Toyota Prius Hybrid ($22,713), absent subsidies. As a public agency that does not pay income tax, DSNY is not eligible for the $4,007 federal tax credit available to federal income tax payers for new hybrid models, for example Fusion Energi Plug-in Hybrid for the first 200,000 vehicles sold, or for the

[11] Newer Chevrolet Volts (2019) can run on battery power alone for up to 53 miles.

similar tax credit of $1,875 to $7,500 that was available for the purchase of a Volt (ended March 31, 2020). Previously, DSNY has used federal Congestion Mitigation and Air Quality (CMAQ) grant funding to cover the incremental cost of the Volts over the cost of a Fusion Energi Plug-in Hybrid, Prius or Fusion. As for operational costs, at current rates, a 2017 Prius that is driven 10,000 miles annually (the average for a DSNY sedan, which is equivalent to 33 miles/day) for 8 years (the useful vehicle life for a DSNY sedan) will require 192 gallons of gasoline per year at a cost of $1.62 per gallon as of December 2020, for a total of $311.04 in annual fuel costs (excluding oil changes, etc). A Fusion Energi Plug-in Hybrid that is driven the same daily distances would drive 19 miles in pure electric mode and 14 miles in gasoline mode and would have $181.44 in gasoline costs, plus the cost of electricity consumed (0.36 kWh/mile at $0.14/kWh), which comes to approximately $299.52, for a total annual fuel and electricity cost of $480.96. Annual maintenance costs in CY 2018 were calculated to be $893.31 for the Prius Hybrid and $496.73 for the Fusion Energi Plug-in.[12] At this annual rate, and assuming constant fuel and electricity rates, the Fusion Energi Plug-in Hybrid would cost approximately $7,000 more than the Prius Hybrid over the life of the car, absent subsidies.[13] Fusion Energi Plug-in gasoline use would be reduced by 42% as compared to the Prius Hybrid, for a savings of 641 gallons over that period. The carbon reduction from this fuel savings would be partially offset by the carbon emissions from the natural gas used to produce about 74% of New York City's electricity to charge the plug-in vehicle.[14] However, the net reduction in carbon emissions would still be substantial.[15] There would be similar incremental costs and gas and carbon savings for the Prius Hybrid Plug-in as compared to the Prius Hybrid.

DSNY has observed no significant difference in performance in the field between the Fusion Energi Plug-in Hybrid, the Volt, the Outlander, the Prius, the RAV4 or the Fusion Hybrid. The Fusion Energi Plug-in Hybrid, the Fusion and Prius have more cargo space than a Volt but this difference is not material for typical DSNY sedan operations; the RAV4 and the Outlander are both SUVs with 4-wheel drive capability, which is important for DSNY winter storm operations. The requirement of charging the Fusion Energi Plug-in Hybrid, the Volt, and the Outlander creates certain operational issues not posed by the Prius, RAV4 or Fusion Hybrid, including a comparatively long charge time (about three hours at 240V at a Level 2 charging station), the limited number of parking spots with charging equipment at DSNY facilities, and the need for electrical upgrades at certain DSNY facilities to accommodate the required amperage for vehicle charging. Furthermore, the required charge time for the Fusion Energi Plug-in Hybrid, the Volt, and the Outlander is inadequate for the Department's 12-hour shifts during snow operations. The environmental benefits of operating a plug-in hybrid over a conventional hybrid for DSNY's fleet (with lower local emissions and lower carbon emissions) can only be obtained via an adequate

[12] City of New York, Department of Citywide Administrative Services, NYC Fleet Newsletter, Issue 255 (March 8, 2019). This information was not updated in CY2019 and CY2020.

[13] The salvage value of the two vehicles is roughly comparable, and not included in this analysis.

[14] Of the electricity used in the downstate region that includes New York City, 74% is from fossil fuel (primarily natural gas), 23% is from zero emission sources (mainly nuclear, some wind and solar), 2% from other renewables such as waste-to-energy plants, and 1% from hydroelectric pumped storage. Figures are for 2016. The Indian Point Energy Center nuclear power plant supplying the region is scheduled to close by April 2021. Source: New York Independent Service Operator, *Power Trends 2017*, p. 31.

[15] Considering the generation mix for New York City, the CO_2-equivalent emissions (grams per mile) are estimated to be 181 for a 2015 Toyota Prius Plug-in, 191 for a 2018 Ford Energi Plug-in, 139 for a 2018 Prius Prime Plug-in, 141 for a 2018 Chevy Volt, and 102 for a 2016 Nissan Leaf (EV). Source: Union of Concerned Scientists, EV Emissions Tool, accessed on March 16, 2020: https://www.ucsusa.org/clean-vehicles/electric-vehicles/ev-emissions-tool.

infrastructure and flexibility in charging time.

The Department expects to take further advantage of the advances in plug-in hybrid electric vehicles, in accordance with the Clean Fleet directive of Mayor de Blasio and consistent with the Department's operational needs. In addition, as DSNY continues to install solar photovoltaic arrays at its garages, this clean, renewable source of electricity will further reduce the carbon footprint of plug-in vehicles and all-electric vehicles in the fleet.

4. Zero-Emission Battery-Electric Vehicles

DSNY operates certain zero-emission battery-electric vehicles (BEVs) in its fleet under the mandate of LL 38/2005; none were added in CY2020, however. In CY2013, DSNY acquired 18 BEV Nissan Leafs for light duty use. Zero-emission vehicles have the potential to bring further benefits to local air quality, as well as fuel cost savings and GHG reduction, compared to DSNY's current hybrid fleet. The improvement over a plug-in hybrid vehicle may be insignificant however, when DSNY sedan usage stays under 19 miles per driving shift, so that the plug-in hybrid vehicle operates primarily in electric mode, as noted above. Moreover, such BEVs require additional charging infrastructure, and may limit DSNY's operational flexibility for such sedans and be impractical in winter emergency snow situations due to relatively slow charging times and lack of four-wheel drive capability that is essential in responding to winter emergency weather.

When a major snowstorm hits the City of New York, DSNY's light-duty fleet (passenger cars and SUVs) becomes part of the Department's snow-removal operation. DSNY's Field Supervisors utilize light-duty vehicles to survey, assess and assist in the snow-removal operation throughout the five boroughs. When snow accumulation reaches six inches or higher, Field Supervisors driving passenger cars experience great difficulty navigating through heavy snow due to low ground clearance and poor traction-control of front-wheel drive passenger cars. Passenger cars that lack four-wheel drive capability can get stuck in the snow, which further hampers the snow removal response as resources must be dedicated to tow these vehicles out, and DSNY loses the function of that Field Supervisor to manage the snow fighting response within the assigned area. Passenger cars impede the Department's ability to safely and effectively survey, assess and assist in the snow-removal operations. As a result, DSNY generally uses hybrid or plug-in hybrid SUVs with four-wheel drive capability in lieu of BEVs and/or plug-in hybrid cars lacking such capability for all jurisdictions responsible for snow-removal operations.

DSNY currently owns/operates one Level-3 and 104 Level-2 EV charging stations citywide, which include a total of 158 charging ports. Level-3 EV chargers are also known as Direct Current Fast Chargers (DCFC) and can deliver a very high rate of charge. Level-3 chargers are more suitable for heavy-duty vehicles with very large battery-packs. Level-2 EV chargers deliver a much lower rate of charge and are more suitable for light-duty passenger vehicles with much smaller battery packs.

In CY2011, DSNY also purchased and is testing two Ford Transit Connects (BEV vans). Both vehicles have been discontinued by the manufacturer. One vehicle was condemned in CY2018; the remaining vehicle continued in use in CY2020 and will remain as part of DSNY's fleet until the end of its useful life.

As new zero-emission vehicles come on the market, DSNY intends to conduct further studies on the economic and operational feasibility of incorporating more alternative fuel light-duty vehicles into its fleet.

B. Heavy-Duty Vehicles

1. Heavy Duty Battery-Electric Vehicles

In the past few years, the development of heavy-duty BEVs has advanced. Cummins, Freightliner, Kenworth, and Mack Trucks are among the truck manufacturers who have announced on-going development of Class-8 BEVs. As noted above, DSNY's EV charging infrastructure has grown over the years to accommodate the increased number of plug-in vehicles in the DSNY fleet. To build on DSNY's experience and success in deploying a fleet of light-duty EVs and continue the progress of reducing GHG emissions from heavy-duty vehicles, DSNY expressed interest to Mack Trucks and Global Environmental Products about exploring the development of a BEV collection truck and street sweeper, respectively. Based on DSNY's pioneering R&D record and expressed interest, both Mack Trucks and Global Environmental Products agreed to begin development of a BEV collection truck and BEV street sweeper, respectively. The pilot/prototype BEV street sweeper and collection truck (see cover photo of this report) are among the first in the country in their weight-class. In anticipation of this pilot, DSNY installed its first Level 3 DC fast charger at DSNY's Brooklyn District 1 Garage, where the BEV collection truck has been assigned.

<u>BEV Collection Truck</u>

Under a written Agreement with Mack Trucks, and at no cost to the City, DSNY is among the first public or private fleets in the country to pilot-test an all-electric BEV collection truck. The term of the pilot is for one year, which will allow DSNY to test the BEV collection truck throughout four seasons and various operating conditions. The DSNY BEV collection truck is the first in its weight class at 72,000 lbs GVW. The BEV collection truck The BEV collection truck features Mack's fully integrated electric powertrain with twin electric motors and four NMC lithium-ion batteries providing vehicle propulsion, as well as power for all onboard accessories. A unique three-mode regenerative braking system takes into account the truck's increasing load and helps recapture energy from the hundreds of stops collection trucks make each day.

DSNY's collection trucks are part of NYC's snow-removal arsenal. Each one of DSNY's collection trucks is equipped with a snowplow hitch. As a pre-production prototype, the DSNY BEV collection truck does not have the capability to plow snow. However, it is anticipated that future generations of BEV collection truck will be able to plow snow.

Due to COVID-19, delivery of the BEV collection truck was extremely delayed. Upon its arrival in September 2020, and after completing initial inspection and mechanic/operator training, the official launch of the Department's first BEV collection truck was on November 18, 2020. DSNY's staff will closely monitor the daily performance of the truck and collect various data points to help in the assessment process when the pilot test concludes.

BEV Street Sweeper

DSNY is among the first public or private fleets in the country to pilot-test an all-electric BEV street sweeper. Under a Research and Development grant funded by NYS Energy & Research Development Authority (NYSERDA), DSNY was awarded $255,000 towards the incremental cost of an all-electric street sweeper (compared to the base cost of a diesel hybrid-electric vehicle (HEV) street sweeper).[16]

The DSNY BEV street sweeper is manufactured by Global Environmental Products (GEP) and is the same "M4" model currently in use by DSNY today. The US Hybrid Corporation (Torrance, CA) designed and built the propulsion on the BEV sweeper. The BEV sweeper incorporates a regenerative braking system designed to capture kinetic energy during braking events when in travel or sweeping modes. Under certain conditions, regenerative braking can help improve the range of BEV. The BEV features a fully integrated electric powertrain with a single traction motor and a 180 kWh battery pack.

After the BEV sweeper arrived in January 2020, DSNY conducted preliminary shakedown testing. DSNY identified various technical issues and worked with GEP and US Hybrid to address them. Due to COVID-19, the official launch of the Department's first BEV sweeper has been delayed; DSNY anticipates it will go into service in March 2021. The BEV sweeper will be assigned to DSNY's Brooklyn District 4 (BK4) garage. The BK4 street sweeping routes are located in a NYC environmental justice community. Under the grant, CalStart will participate in the BEV street sweeper program by assisting in the data collection process and preparing periodic and final reports as outlined by NYSERDA. DSNY staff will closely monitor the daily performance of the truck and collect various data points to help in the assessment process when the pilot test concludes.

2. Compressed Natural Gas (CNG)

DSNY currently owns and operates 39 dedicated CNG sanitation collection trucks, including a new design for 6 CNG trucks acquired in CY2020 (see Appendix 1). DSNY phased out its older fleet (2001-2003 vintage) of CNG collection trucks that were problematic. CNG-fueled trucks are longer than conventional sanitation vehicles, making it more difficult to access certain narrower streets because of their wider turning radius. In CY 2008, DSNY put into service 10 new CNG collection trucks from Crane Carrier Corporation equipped with the new generation of the Cummins ISL-gas CNG engines to replace 10 of the oldest CNG trucks in the fleet. In CY 2009, DSNY put into service one front-loading Crane Carrier Corporation CNG collection truck equipped with a Cummins ISL-gas CNG engine. Also in CY 2009, DSNY ordered 10 additional CNG trucks from Crane Carrier Corporation, which were delivered in November/December 2009. In order to address the repeated failed cold starts of the fleet of Crane Carrier CNG trucks, at DSNY's request Cummins made improvements to the engine calibration software. With the problem corrected, DSNY formally added the last 10 Crane Carrier CNG trucks to the fleet in the third quarter of CY 2010. The cold-weather operation of the newest CNG trucks with the Cummins ISL-Gas CNG engines has been satisfactory. In CY 2013, DSNY ordered and received delivery of 23 additional CNG trucks from Mack Trucks, equipped with a Cummins ISL-gas CNG engine. DSNY

[16]The cost of an HEV street sweeper is $379,800. The cost of a BEV street sweeper is $734,800.

put these 23 additional trucks into service in January 2014.

From an operational perspective, results on testing the latest generation of CNG collection trucks indicate they have improved in reliability from earlier model CNG trucks, but they are still not as reliable as clean diesel trucks. NOx emissions from the two technologies have been comparable; with CNG truck NOx emissions slightly lower than the NOx emissions from diesel trucks with advanced after-treatment technologies.[17] As a result of the use of ULSD and new emissions control technologies, heavy duty diesel truck PM emissions are very low, and are comparable to those from CNG-fueled heavy duty vehicles. On the other hand, GHG emissions from CNG trucks are reportedly 20-23% lower than those from diesel trucks.[18] It has been noted that CNG trucks are somewhat quieter than diesel trucks,[19] but compaction noise from CNG collection trucks and diesel collection trucks is generally comparable.

From an economic perspective, with increased recoverable domestic reserves due to new technology natural gas prices have fallen and have been competitive with diesel prices. As of December 2020, a gallon of diesel fuel cost $2.13 while a gallon-equivalent of CNG cost approximately $2.50; in February 2020, a gallon of diesel fuel cost $2.36 while a gallon-equivalent of CNG cost approximately $2.57. CNG-fueled vehicles have lower fuel efficiency than diesel and a CNG-fueled collection truck costs approximately $24,114 more per unit than a diesel collection truck[20]. For a collection truck that drives 6900 miles in a year at an average 2.5 miles per gallon, the annual diesel fuel cost at $2.13/gal is $5,879 (versus last year's annual cost of $6,514); the equivalent in CNG fuel at $2.50/gal eq. is $6,900 (versus last year's annual cost of $7,093). Further, DSNY has only one CNG fueling station for its 59 district garages,[21] and the handful of private CNG filling stations in the City are generally not equipped for rapid filling of heavy-duty trucks. Thus, any move to significantly expand DSNY's CNG truck fleet would require additional investment to build CNG fueling infrastructure and undertake facility modifications required by the New York City Building Code.

In October 2015, Cummins announced that its new ISL G Near Zero (NZ) NOx natural gas engine is the first Mid-Range engine in North America to receive emission certifications from both USEPA and CARB as meeting the 0.02 g/bhp-hr optional Near Zero NOx Emissions standards for collection trucks. Cummins ISL GNZ NOx emissions will be 90% lower than the current USEPA NOx limit of 0.2 g/bhp-hr which is even cleaner than clean diesel. In FY2018, DSNY purchased 6 new Mack Trucks powered by the Cummins ISL GNZ CNG engine for its fleet; DSNY put these 6 trucks in service in CY2020.

As explained in prior annual reports, DSNY has previously completed the LL38/2005-mandated evaluation pilot study of CNG sweepers. DSNY currently has no CNG sweepers in

[17] Ayala, *et al.*, *CNG and Diesel Transit Bus Emissions in Review* (August 2003); Ayala, *et al.*, *Diesel and CNG Heavy-Duty Transit Bus Emissions over Multiple Driving Schedules: Regulated Pollutants and Project Overview* (Society of Automotive Engineers, 2002).
[18] Peter Hildebrandt, "NGVs & Onboard Equipment," *MSW Management*, March/April 2011, *NGV Fleet Manager Supplement*, at 14 (citing figures from Clean Vehicle Education Foundation).
[19] INFORM, Inc., *Greening Garbage Trucks: New Technologies for Cleaner Air* (2003).
[20] Cost as of 2019. In 2019, CNG-fueled collection trucks were redesigned.
[21] This project was undertaken as part of a settlement of a lawsuit brought against the City and DSNY by the United States for violations of the Clean Air Act. *United States v. City of New York*, 99 Civ. 2207 (LAK) (S.D.N.Y.).

service.

3. Heavy Duty Hybrid-Electric Vehicles (HEV)

DSNY is currently testing 27 diesel-powered HEV street sweepers in eight districts (see Appendix 2). In CY2010, DSNY put into service the world's first Class-7 HEV street sweeper. In FY2019, DSNY purchased seven diesel-powered HEV street sweepers at $379,800 per vehicle (five of which were subsidized by $30,000 in CMAQ funds each), which is $125,000 more than the purchase price of a conventional diesel sweeper. In FY2020, DSNY purchased 14 more diesel-powered HEV street sweepers. All 14 HEV street sweepers have been inspected, accepted and put into service. All 14 units are equipped with an export-power module which gives these vehicles the ability to provide up to 10kW of shore power to a DSNY garage facility in the event of a blackout. Preliminary test results indicate that these diesel HEV street sweepers have better fuel mileage and are approximately 42% more fuel efficient than the latest Clean Diesel engines. DSNY continues to collect service records throughout the evaluation process.

4. Hybrid-Hydraulic Diesel Collection Trucks

As discussed in prior Annual Reports, hybrid-hydraulic technology has the potential to reduce diesel fuel use and related emissions by capturing and reusing energy that is otherwise wasted during the frequent braking of collection vehicles. DSNY ordered two experimental (prototype) hybrid-hydraulic diesel trucks from Crane Carrier Corporation in 2008, which were put into service in October 2009. This initiative was sponsored by the New York State Energy Research and Development Authority and the Hybrid Truck Users Forum. The hybrid-hydraulic diesel trucks utilize Bosch Rexroth's HRB System technology. These were the first such trucks in North America; they have also been tested in Germany. In CY2013, DSNY put into service 17 additional next-generation Bosch Rexroth hybrid-hydraulic trucks. DSNY applied for and obtained federal CMAQ grant funds for 80% of the cost of these new purchases. Also in CY2013, DSNY successfully applied for federal CMAQ grant funding to purchase 32 additional diesel-powered hybrid-hydraulic trucks from Mack Trucks for CY2014 delivery. Currently, DSNY has a total of 46 hybrid-hydraulic diesel trucks in service.

Due to the dramatic drop in the price of diesel fuel that ultimately eliminated the potential for return on investment for hybrid-hydraulic system manufacturers, these manufacturers have discontinued production of the hybrid-hydraulic trucks. Therefore, currently DSNY has no viable option for new hybrid-hydraulic heavy duty trucks. Because the manufacturer can no longer support this first-generation design, the hybrid-hydraulic technology had to be disabled on the first two Crane Carrier diesel-powered collection trucks. The 46 hybrid-hydraulic collection trucks in the fleet will continue in service until they reach the end of their operational life.

C. Testing of Biodiesel Blends

Biodiesel is a renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease. It is a cleaner-burning replacement for petroleum-based diesel fuel. The biodiesel fuel used by DSNY comes from soybeans. Biodiesel reduces GHG emissions because CO_2 released from biodiesel combustion is largely offset by the CO_2

absorbed from growing soybeans or other feedstocks used to product the fuel.[22] LL 73/2013 requires the use of biodiesel fuel in diesel fuel-powered motor vehicles owned or operated by the city of New York. According to LL 73/2013, for fiscal year beginning July 1, 2014, these vehicles must use at least five percent biodiesel (B5) by volume. In March 2007, DSNY launched a biodiesel (B5) initiative citywide on all diesel-powered equipment (on- highway and off-highway), utilizing 5% biodiesel (made from soybeans) and 95% (petroleum-based) ULSD. To date, the B5 initiative resulted in no change in vehicle performance, no operator or mechanic complaints, no increase in down rate, and good winter operability.

Pursuant to LL 73/2013, beginning July 1, 2016, all diesel-powered motor vehicles owned or operated by the city of New York must use B5 from December through March, and at least B20 (20% biodiesel) from April through November. LL 73/2013 also established a pilot program beginning December 1, 2016 whereby at least five percent of all city-owned diesel-powered motor vehicles utilize at least B20 from December through March.

Previously, in 2008, DSNY implemented its B20 pilot study (April through November) in Queens District 6. Based on those encouraging results, in July 2010 DSNY expanded the study to Brooklyn District 5. In advance of the LL 73/2013 mandate beginning July 1, 2016 DSNY expanded the B20 pilot study (April through November) citywide in CY 2013 (59 districts).

Since July 2008, DSNY's fleet has consumed over 42 million gallons of B20 biodiesel. Over the past few years, DSNY gradually increased the use of B20 (winter pilot) at various districts during winter months (December through March). During the 2018-2019 B20 winter pilot, DSNY dispensed B20 in 21 districts of the City and took proactive steps to mitigate/prevent potential operational issues with vehicles and fuel dispensers. About one month into the 2018-2019 B20 winter pilot, DSNY suspended B20 deliveries to the three locations utilizing above-ground fuel storage tanks due to persistent plugging and replacement of the fuel dispenser filters. To reduce the risk of fuel gelling/crystallization of the B20 product during extreme single-digit ambient temperatures, DSNY dispensed an anti-gel diesel fuel additive in all vehicle fuel tanks operating on B20. These steps helped DSNY to continue and complete the B20 winter pilot without any further operational issues. Test results of random fuel samples indicated the B20 biodiesel met all ASTM testing specifications during the winter and summer months. During the 2019-2020 and 2020-2021 winters, DSNY discontinued the B20 winter pilot and dispensed only B5 citywide at its 59 districts to minimize the risks encountered during the 2018-2019 B20 winter pilot and avoid the hardship of constantly addressing operational issues (i.e., ensuring proper additive dosing) at B20 locations.

B5 biodiesel costs slightly more than standard ULSD, while B20 biodiesel costs approximately $0.17 more per gallon than B5. In FY2020 DSNY used 8,154,131 gallons of diesel of various blends, of which 60% was B20 biodiesel and 40% was B5 biodiesel. The use of these grades of biodiesel reduced GHG emissions from the fleet in 2020 by 34,117 metric tons of CO2, from the FY2005 diesel fleet baseline, a 31% reduction. Using B20 yielded a net reduction in carbon

[22] About 22.4 pounds of CO_2 is produced from burning a gallon of ULSD; about 17.9 pounds of CO_2 is produced from burning a gallon of B20. Source: U.S. Energy Information Agency, accessed March 21, 2018 https://www.eia.gov/tools/faqs/faq.php?id=307&t=11.

emissions of approximately 20% compared to conventional fossil fuel diesel use.[23] To date, DSNY's use of biodiesel blends has displaced well over twelve million gallons of petroleum-based diesel fuel. Good housekeeping of underground storage tanks (UST) and proper vehicle maintenance are key to a successful biodiesel program.

D. Renewable Diesel

Hydrogenation-derived Renewable Diesel, also known as Renewable Diesel (RD), is produced from soybean, palm, canola, or rapeseed oil; animal tallow; vegetable oil waste or brown trap grease; and other fats or vegetable oils. It can be used alone (100%) or blended with petroleum and refined by a hydro treating process. RD meets the petroleum diesel ASTM specification (D975), which allows it to be used in existing diesel infrastructure and vehicles. RD derived from domestic biological materials is considered an alternative fuel under the Energy Policy Act of 1992 (Public Law 102-486). RD is a renewable fuel which has the potential to reduce GHG emissions over 60% compared to fossil-fuel petroleum-based diesel. Benefits of using RD include:

- **Fewer emissions**—RD feedstocks capture and recycle CO2 from the atmosphere, partially offsetting CO2 from burning RD, and blends of RD can reduce carbon monoxide and hydrocarbon emissions. In addition, RD's ultra-low sulfur content enables the use of advanced emission control devices.

- **More flexibility**—RD that meets quality standards can fuel modern diesel vehicles. This fuel is compatible with existing diesel distribution infrastructure (not requiring new pipelines, storage tanks, or retail station pumps), can be produced using existing oil refinery capacity, and does not require extensive new production facilities.

- **Higher performance**—RD's high combustion quality results in similar or better vehicle performance compared to conventional diesel.

DSNY was one of several city agencies participating in the NYC Renewable Diesel pilot, which utilizes a blend of 99% RD with 1% petroleum diesel. The pilot commenced upon receiving a June 13, 2018 Letter of No Objection from the New York City Fire Department. DSNY was the first city agency to receive a delivery of RD, at the Queens District 6 Garage in Woodside. DSNY gradually expanded the RD pilot to 17 district garages in all five boroughs. DSNY consumed 653,218 gallons of RD throughout the five-month period of the pilot program (June 2018 through October 2018). Test results of random fuel samples indicated that the RD met all ASTM testing specifications. RD did not negatively impact DSNY's fleet or its operation, and no adjustments were necessary to the preventive maintenance schedule of the DSNY fleet. Although the pilot has ended, the use of RD in the future could help the agency achieve OneNYC's fleet GHG reduction goals. Despite delays due to COVID-19, DCAS is in the process of evaluating bids for RD and anticipates having a two-year RD contract in place by March/April 2021.

[23] To date, since 2008 DSNY's use of B20 has resulted in the saving of approximately 190,109,696 pounds of CO_2.emissions.

E. Active Stop-Start Technology

As part of the City's goal to reduce fleet GHG emissions 80% by 2035, DSNY is also exploring the use of idle-stop technology designed to reduce/eliminate unnecessary idling. DSNY is currently pilot testing 12 collection trucks equipped with the Effenco Stop/Start technology. The Effenco Stop/Start technology is specifically designed for use in heavy-duty vehicles. Fourteen additional collection trucks equipped with the Effenco technology were to be delivered to DSNY in CY2020 but the delivery was delayed due to COVID-19. The first truck arrived in December 2020; complete delivery of the remaining thirteen trucks is projected to take place in CY2021. Effenco's Active Stop-Start Technology is an electric system using ultracapacitor modules that is 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 HVAC system. Since these vehicles spend a large proportion of their operating time immobile, the Active Stop-Start technology creates value by reducing engine operating hours and corresponding fuel consumption, emissions and maintenance. On a preliminary basis, DSNY has found a 30-40% reduction in fuel use and GHG emissions with this technology.

V. Conclusion

DSNY endeavors to operate its fleet in the most environmentally sustainable manner, consistent with available resources, and therefore seeks to minimize emissions of concern from such operations, notably PM, NOx, and greenhouse gases such as CO2. DSNY is nationally recognized for its experience with alternative fuels and pioneering efforts with low emission technologies and has received a number of awards for operating one of the greenest municipal fleets in the country. The Department is currently working with various manufacturers to help advance the commercialization of environmentally-friendly technologies designed for use in heavy-duty vehicles.

Mayor De Blasio's Executive Order 53 seeks to expand on NYC's leadership in fleet sustainability and will allow NYC to serve as a national model for other 21st century cities in fighting climate change. The goal of the Order is for the City of New York to achieve an all-electric, carbon-neutral fleet by the year 2040. As discussed above, DSNY is advancing a pilot study to incorporate BEV street sweepers and collections trucks into its fleet, as well as continuing to incorporate zero-emission light-duty BEVs into its fleet. Achieving the ambitious goal of Executive Order 53 is expected also to require expanding the use of anti-idling, hybrid, and stop-start technologies in medium- and heavy-duty vehicles and increasing the use of alternatives to traditional diesel fuels, including renewable diesel.

DSNY has dramatically reduced fuel consumption and GHG emissions from its fleet of light-duty vehicles from the 2005 baseline. DSNY will continue to participate in research and development of new technologies and to evaluate the mechanical reliability and operability of alternative fuel collection trucks to assess their respective environmental and economic performances. DSNY's B20 initiative citywide has met with positive results. This initiative has the potential to further reduce truck emissions, including greenhouse gases. Also, DSNY hopes to add RD to its portfolio of reduced GHG renewable fuels. DSNY is committed to achieving the goals of Executive Order 53 and the NYC Clean Fleet Plan and sustainable fleet GHG reduction.

Appendix 1: DSNY's CNG Collection Trucks

Vehicle ID	Make	Vehicle Type	VIN #
25CNG-507	Crane Carrier LET2	Rear Loading	1CYCCZ48X8T048574
25CNG-508	Crane Carrier LET2	Rear Loading	1CYCCZ4818T048575
25CNG-509	Crane Carrier LET2	Rear Loading	1CYCCZ4838T048576
25CNG-510	Crane Carrier LET2	Rear Loading	1CYCCZ4858T048577
25CNG-601	Crane Carrier LET2	Rear Loading	1CYCCZ4819T049419
25CNG-602	Crane Carrier LET2	Rear Loading	1CYCCZ4889T049420
25CNG-603	Crane Carrier LET2	Rear Loading	1CYCCZ48X9T049421
25CNG-604	Crane Carrier LET2	Rear Loading	1CYCCZ4819T049422
25CNG-605	Crane Carrier LET2	Rear Loading	1CYCCZ4839T049423
25CNG-606	Crane Carrier LET2	Rear Loading	1CYCCZ4859T049424
25CNG-608	Crane Carrier LET2	Rear Loading	1CYCCZ4899T049426
25CNG-609	Crane Carrier LET2	Rear Loading	1CYCCZ4809T049427
25CNG-701	Mack	Rear Loading	1M2AU14C4DM001603
25CNG-702	Mack	Rear Loading	1M2AU14C6DM001604
25CNG-703	Mack	Rear Loading	1M2AU14C8DM001605
25CNG-721	Mack	Rear Loading	1M2AU14C9DM001709
25CNG-722	Mack	Rear Loading	1M2AU14C5DM001710
25CNG-723	Mack	Rear Loading	1M2AU14C7DM001711
25CNG-724	Mack	Rear Loading	1M2AU14C9DM001712
25CNG-725	Mack	Rear Loading	1M2AU14C0DM001713
25CNG-726	Mack	Rear Loading	1M2AU14C2DM001714
25CNG-727	Mack	Rear Loading	1M2AU14C4DM001715
25CNG-728	Mack	Rear Loading	1M2AU14C6DM001716
25CNG-729	Mack	Rear Loading	1M2AU14C8DM001717
25CNG-730	Mack	Rear Loading	1M2AU14CXDM001718

25CNG-731	Mack	Rear Loading	1M2AU14C9DM001726
25CNG-732	Mack	Rear Loading	1M2AU14C0DM001727
25CNG-733	Mack	Rear Loading	1M2AU14C2DM001728
25CNG-734	Mack	Rear Loading	1M2AU14C4DM001729
25CNG-735	Mack	Rear Loading	1M2AU14C0DM001730
25CNG-736	Mack	Rear Loading	1M2AU14C2DM001731
25CNG-737	Mack	Rear Loading	1M2AU14C4DM001732
25CNG-738	Mack	Rear Loading	1M2AU14C6DM001733
25CNG-739	Mack	Rear Loading	1M2AU14C8DM001734
25CNG-740	Mack	Rear Loading	1M2AU14CXDM001735
25CNG-803	Mack	Rear Loading	1M2LR7GC1LM001260
25CNG-804	Mack	Rear Loading	1M2LR7GC3LM001261
25CNG-805	Mack	Rear Loading	1M2LR7GC5LM001262
25CNG-806	Mack	Rear Loading	1M2LR7GC7LM001263

Appendix 2 : DSNY's Hybrid-Electric Street Sweepers

Vehicle ID	**Make**	**Vehicle Type**	**VIN #**
25XG-001	Global Environmental Products	Street Sweeper	1CYCCZ48X9T049418
20XG-001	Global Environmental Products	Street Sweeper	1G9GM4LL3JS462063
20XG-002	Global Environmental Products	Street Sweeper	1G9GM4LL5JS462064
20XG-003	Global Environmental Products	Street Sweeper	1G9GM4LL7JS462065
20XG-004	Global Environmental Products	Street Sweeper	1G9GM4LL9JS462066
20XG-005	Global Environmental Products	Street Sweeper	1G9GM4LL0JS462067

20XG-006	Global Environmental Products	Street Sweeper	1G9GM4LL2JS462068
20XG-007	Global Environmental Products	Street Sweeper	1G9GM4LL4JS462069
20XG-101	Global Environmental Products	Street Sweeper	1G9GH4LL6KS462001
20XG-102	Global Environmental Products	Street Sweeper	1G9GH4LL8KS462002
20XG-103	Global Environmental Products	Street Sweeper	1G9GH4LLXKS462003
20XG-104	Global Environmental Products	Street Sweeper	1G9GH4LL1KS462004
20XG-105	Global Environmental Products	Street Sweeper	1G9GH4LL3KS462005
20XG-106	Global Environmental Products	Street Sweeper	1G9GH4LL5KS462006
20XG-107	Global Environmental Products	Street Sweeper	1G9GH4LL7KS462007
20XG-201	Global Environmental Products	Street Sweeper	1G9FH7A25LS462015
20XG-202	Global Environmental Products	Street Sweeper	1G9FH7A27LS462016
20XG-203	Global Environmental Products	Street Sweeper	1G9FH7A29LS462017
20XG-204	Global Environmental Products	Street Sweeper	1G9FH7A20LS462018
20XG-205	Global Environmental Products	Street Sweeper	1G9FH7A22LS462019
20XG-206	Global Environmental Products	Street Sweeper	1G9FH7A29LS462020
20XG-301	Global Environmental Products	Street Sweeper	1G9FH7A20LS462021
20XG-302	Global Environmental Products	Street Sweeper	1G9FH7A22LS462022
20XG-303	Global Environmental Products	Street Sweeper	1G9FH7A24LS462023
20XG-304	Global Environmental Products	Street Sweeper	1G9FH7A23MS462001
20XG-305	Global Environmental Products	Street Sweeper	1G9FH7A25MS462002
20XG-306	Global Environmental Products	Street Sweeper	1G9FH7A27MS462003

20XG-307	Global Environmental Products	Street Sweeper	1G9FH7A29MS462004
20XG-308	Global Environmental Products	Street Sweeper	1G9FH7A20MS462005