The City of New York
Department of Sanitation

2022 Annual Report on Alternative Fuel Vehicle Programs
Pursuant to Local Law 38 of 2005

NYC's First Battery-Electric Mechanical Broom

July 2023

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 2022 Report

- DSNY's fleet of 5,871 heavy duty and light duty vehicles has 828 vehicles that operate on various alternative fuels (16.2%), including electric, hybrid-electric and natural gas.
- DSNY is now testing 14 trucks with next generation "stop-start" ultra-capacitor technology to reduce emissions by shutting off the engine when idle, with the potential to reduce fuel use and emissions by up to 30%.
- In FY2022, DSNY collection truck fleet traveled 11,877,992 vehicle miles, mechanical brooms traveled 1,252,467 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: 2,201 diesel and 35 natural gas.
- Mechanical Brooms: 393 diesel, 33 hybrid-electric, and 1 electric.
- Light Duty Fleet: 144 battery-electric, 350 gas-electric hybrids, 236 plug-in hybrid–electric, and 356 gasoline.
- In FY2022, DSNY's fleet consumed approximately 9.1 million gallons of B5 to B20 biodiesel fuel, and 452,551gallons 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.
- DSNY gasoline use in FY2022 has declined by 61% 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 2023, DSNY's active fleet of 5,871 vehicles includes 2,236 collection trucks, 426 street sweepers, 429 salt/sand spreaders, 442 front-end

[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.

[3] PM, especially fine PM 2.5 microns in diameter or smaller ($PM_{2.5}$) is associated with increased respiratory symptoms (including exacerbations of asthma), 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*, 88 Federal Register at 4296 (Jan. 24, 2023); "Public Health" chapter in *New York City Comprehensive Solid Waste Management Plan Final Environmental Impact Statement* (April 2005).

loaders, 1,190 light-duty vehicles and 1,148 various other support vehicles. Based on Fiscal Year 2022 figures, DSNY's diesel fleet used approximately 9.1 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 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 2019 -2021 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 2019-2021 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. In addition, since 2005 DSNY's fleet has cut annual diesel fuel use by 13% (9,153,567 gallons of B5 and B20 biodiesel consumed in FY2022) and cut its light duty fleet gasoline use by 61% (452,551 gallons consumed in FY2022).

[4] NYC Administrative Code § 24-163.2(a)(6).
[5] The annual PM2.5 NAAQS is the 3-year average annual mean concentration.

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 regulated clean-diesel engines that yield much lower tailpipe emissions and greenhouse gases 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 and partnering with industry to test vehicles under real world conditions.

- 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 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, 2023 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

[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: 1990-2020. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

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, most of which were delivered in CY2021. In FY2021, DSNY ordered 93 new diesel-powered collection trucks and 7 new BEV collection trucks. These trucks comply with EPA Phase-1 GHG standards. In FY2022 DSNY ordered 289 new diesel-powered collection trucks; in FY2023 DSNY plans to purchase 244 (154 single & 90 dual) new diesel-powered collection trucks. These new trucks will comply with EPA Phase-2 GHG standards, adding to the 289 Phase-2 GHG-compliant collection trucks acquired previously.

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 828 vehicles that operate on various alternative fuels, including electric and hybrid-electric vehicles.

In December 2021, Executive Order 90 was issued with the goal of New York City accelerating the adoption of an all-electric fleet:

> a. By 2030, all light duty on-road vehicles will be electric models except those vehicles assigned to law enforcement and emergency response as defined by the State Vehicle and Traffic Law (YTL).
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> b. By 2035, all light duty and medium duty on-road fleet vehicles, including those assigned to law enforcement and emergency response will be converted to electric models, and all non-emergency trucks will be converted to electric models. Emergency and specialized trucks will be converted to electric models no later than 2040.
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> DSNY is exploring options for fleet compliance with this goal.

A. Light-Duty Vehicles

DSNY's light duty fleet currently includes 730 advanced low- or zero-emission vehicles, such as hybrid-electric, plug-in hybrid-electric (PHEVs), and battery-electric vehicles (BEVs). Hybrid-

[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.

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 Executive Order 90 of 2021, DSNY expects to increase its fleet of light-duty electric vehicles.

1. Hybrid-Electric Vehicles

DSNY currently owns and operates 350 hybrid-electric vehicles. These include Ford Fusion and Escape, Toyota Prius and RAV4. DSNY has not purchased any hybrid-electric light duty vehicles since FY2019.

2. Plug-In Hybrid-Electric Vehicles

DSNY's fleet includes 236 plug-in hybrid–electric vehicles. These include Chevrolet Volt sedans, Ford Fusion Energi Plug-in Hybrids, and Mitsubishi Outlander Plug-in 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 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. 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.

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 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 every DSNY facility 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 infrastructure and flexibility in charging time.

The Department expects to take further advantage of the advances in plug-in hybrid electric vehicles, 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 owns and operates 144 zero-emission BEVs for light duty use in its fleet under the mandate of LL 38/2005 and Executive Order 90 of 2021.These include BEV Nissan Leafs, Chevy Bolts, Ford E-Transits, Ford Mustang Mach-E and Ford F150 Lightnings.

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. However, 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 116 Level-2 EV charging stations citywide, which include a total of 200 charging ports, 51 Direct Current Fast Chargers (DCFC)[9], and 18 new solar car ports. Level-3 EV chargers are also known as 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.

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

[9] 50 of the 51 DCFC were funded by DCAS.

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 DCFC at DSNY's Brooklyn District 1 Garage, where the BEV collection truck was assigned.

BEV Collection Truck

Under a Memorandum of Understanding (MOU) and at no cost to the City, on November 18, 2020, DSNY commenced pilot-testing one of the first Mack (LR model) BEV refuse collection trucks. The cab/chassis specifications of the Mack BEV LR are identical to the current DSNY diesel collection truck (72,000 lb. GVW). DSNY installed its first DCFC to accommodate the charging needs of the Mack BEV LR. After one year (term of MOU) of rigorous testing in the streets of NYC, the Mack BEV LR yielded impressive test results (payload, state of charge [SOC], uptime, performance) and was well received by DSNY sanitation workers.

As a pre-production unit, this first Mack BEV LR was not originally designed to plow snow. However, due to the mutual interest in collecting data, Mack and DSNY agreed to upfit the truck with a snow plow hitch to give it the ability to plow snow. DSNY was able to plow snow utilizing the Mack BEV LR on the only two days of snow activity during the pilot period. This preliminary data revealed that the truck lasted no more than two hours on a full charge for plowing snow. Based on these results, Mack is working to develop and advance the technology in its BEV LR collection trucks.

Taking into considering the introduction of Executive Order 90 of 2021 which orders the City fleet to be 100% electric by 2035, and as a result of the performance metrics described above, for the next phase of testing (R&D) and in the interest of collecting in-use data, DSNY has decided to move forward with the procurement of seven Mack BEV LR units. DSNY modified the FY2021 Capital Plan to include the procurement of seven Mack BEV LR collection trucks. DSNY will use federal Congestion Mitigation and Air Quality Improvement Program (CMAQ) funds to help pay for the incremental cost of the seven BEV LRs.

The next phase of testing (R&D) will allow DSNY to assess the seven Mack BEV LRs for refuse collection as well as expand the testing to one truck per geographical zone. Each of the seven zones (five boroughs) presents a unique set of operational challenges (terrain, length of routes, tonnage, commodity type, traffic, etc.). DSNY worked closely with DCAS to facilitate the installation of 12 DCFC within the seven zones of operation. The installation of the 12 DCFC is complete. DSNY expects delivery of the seven Mack BEV LRs in CY2023.

BEV Street Sweeper

DSNY was 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).[10]

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 was delayed; the BEV sweeper went into service on May 6, 2021. The BEV sweeper was assigned to DSNY's Brooklyn District 4 (BK4) garage. The BK4 street sweeping routes are located in a NYC environmental justice community. After one year of rigorous testing in the streets of New York City, the BEV sweeper yielded impressive test results (payload, SOC, uptime, performance) and was well received by DSNY sanitation workers. 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. The CalStart final report was released in January 2023 and found that the BEV is capable of performing the duty cycle of a conventional diesel street sweeper, however the BEV maintenance costs were higher than a conventional diesel street sweeper. DSNY staff will closely monitor the daily performance of the truck and collect various data points to help in the assessment process now that the pilot test concluded.

BEV Bike Lane Sweepers

The challenge of sweeping and cleaning over 600 protected bike lane miles in NYC has become one of DSNY's key responsibilities. Being mindful of our environment, DSNY decided to test the effectiveness of utilizing battery electric bike lane sweepers. As the number of protected bike lane miles grows over time, DSNY seeks to facilitate the sweeping service in an environmentally-friendly and sustainable approach. The manufacturer of the battery-electric bike lane sweeper is AEBI Schmidt. The eSwingo 200^{+} is the first fully electric compact sweeper from Schmidt. It is ideal for daily cleaning and sweeping duties of inner-city and pedestrian walkways. In FY2023, DSNY ordered 9 new battery-electric bike lane sweepers from AEBI Schmidt. The first battery-electric bike lane sweeper arrived in April 2023. The delivery of the last eSwingo 200^{+} should be completed by the fourth quarter of 2023. With a battery pack of 75 kWh, the eSwingo 200^{+} will have an operating range of approximately 10 hours. The eSwingo 200^{+} is only capable of charging via Level-2, which means the battery pack can be fully charged in less than eight hours. DSNY looks forward to the testing and addition of battery-electric bike lane sweepers to its portfolio of electric vehicles in the fleet.

[10]The cost of an HEV street sweeper is $431,817. The cost of a BEV street sweeper is $614,860.

2. Compressed Natural Gas (CNG)

DSNY currently owns and operates 35 dedicated CNG sanitation collection trucks, including a new design for 6 CNG trucks acquired in CY2020. 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 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.[11] 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.[12] It has been noted that CNG trucks are somewhat quieter than diesel trucks,[13] but compaction noise from CNG collection trucks and diesel collection trucks is generally comparable.

DSNY has only one CNG fueling station for its 59 district garages,[14] 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

[11] McCaffery, *et al., Real-world NOx emissions from heavy-duty diesel, natural gas, and diesel hybrid electric vehicles of different vocations on California roadways*, (Science of The Total Environment, Volume 784, 2021, 147224 (https://www.sciencedirect.com/science/article/pii/S0048969721022956); 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).

[12] Peter Hildebrandt, "NGVs & Onboard Equipment," *MSW Management*, March/April 2011, *NGV Fleet Manager Supplement*, at 14 (citing figures from Clean Vehicle Education Foundation).

[13] INFORM, Inc., *Greening Garbage Trucks: New Technologies for Cleaner Air* (2003).

[14] 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.). The fueling station was decommissioned in 2020.

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 service.

3. Heavy Duty Hybrid-Electric Vehicles (HEV)

DSNY is currently testing 33 diesel-powered HEV street sweepers in eight districts. 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 was $125,000 more than the purchase price of a conventional diesel sweeper. In FY2020, DSNY purchased 14 more diesel-powered HEV street sweepers.[15] 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. DSNY has found that these diesel HEV street sweepers have better fuel mileage and are approximately 40% more fuel efficient than the latest Clean Diesel engines.

4. Heavy Duty Plug-In Hybrid-Electric Vehicles (PHEV)

With resiliency in mind and the challenges of building an adequate EV charging infrastructure citywide, DSNY commissioned the design and construction of the world's first Plug-in Hybrid Electric (PHEV) street sweepers. In FY2023, DSNY ordered thirty (30) new PHEV street sweepers from Global Environmental Products. The PHEV street sweeper is the same make and model as the diesel and hybrid street sweepers currently in use today by DSNY. As street sweepers are currently assigned to eighty percent of DSNY garages citywide, having a sustainable plan is of the utmost importance. With a battery pack of 35 kWh, this new PHEV street sweeper will have an EV (full electric) range of approximately 30 miles. The PHEV street sweeper will be capable of charging via Level-2 only, which means the battery pack can be fully charged in less than four hours. DSNY utilized Congestion Mitigation Air Quality (CMAQ) funding to aid in the purchase of the PHEV street sweepers. The first PHEV street sweeper is due the third quarter of 2023. The delivery of the last PHEV street sweeper should be completed by the end of CY2024. DSNY looks forward to the addition of PHEV street sweepers into the DSNY fleet.

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

[15] The current price of an HEV street sweeper is $431,817 versus $309,867 for a conventional diesel street sweeper.

soybeans or other feedstocks used to product the fuel.[16] 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 46 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, 2020-2021 and 2021-2022 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 $0.36 more per gallon than B5. In FY2022 DSNY used 9,153,567 gallons of diesel of various blends, of which 58% was B20 biodiesel and 42% was B5 biodiesel. The use of these grades of biodiesel reduced GHG emissions from the fleet in 2022 by 12.3 metric tons of CO2, from the FY2005 diesel fleet baseline, a 23% reduction. Good housekeeping of underground storage tanks (UST) and proper vehicle maintenance are key to a successful biodiesel program.

D. Renewable Diesel

[16] 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 June 2, 2023 https://www.eia.gov/environment/emissions/co2_vol_mass.php.

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 NYC's municipal fleet reduce GHG emissions. DSNY would welcome the use of RD in the future.

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.

Executive Order 90 of 2021 sought 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 ambitious goal of the Order is for the City of New York to achieve an all-electric fleet by the year 2035. As discussed above, DSNY will continue to assess the industry's ability to produce and deliver

BEVs across every vehicle class and type. DSNY seeks to incorporate more BEV street sweepers into its fleet, as well as continuing to incorporate zero-emission light-duty BEVs into its fleet.

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 will continue to assess its sites and build EV infrastructure and work with local utilities to receive service upgrades. DSNY is committed to achieving the goals of Executive Order 90 of 2021.

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