The City of New York
Department of Sanitation

2017 Annual Report on Alternative Fuel Vehicle Programs
Pursuant to Local Law 38 of 2005

Model Year 2014 Hybrid-Electric Street Sweeper

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DSNY Annual Report on Alternative Fuel Vehicle Programs Pursuant to LL38/2005

Introduction

The Department of Sanitation (DSNY) operates a sizeable fleet of trucks and other vehicles to carry out its mission of refuse and recyclables collection, street cleaning and snow removal. In 2005, the City Council enacted Local Law 38 (LL38/2005), which, among other things, directs DSNY to test alternative fuel street sweeping vehicles, and 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. It also reviews the results of DSNY's 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.[2]

DSNY endeavors to operate its fleet in the most environmentally friendly manner, consistent with available resources, and therefore seeks to minimize emissions of concern from such operations, notably particulate matter (PM), nitrogen oxides (NOx), and greenhouse gases such as carbon dioxide.[3] As of January 2018, DSNY's active fleet includes 2,419 collection trucks, 443 street sweepers, 414 salt/sand spreaders, 447 front end loaders and 2,466 various other support vehicles. Based on Fiscal Year 2017 figures, the entire diesel fleet used approximately 10.4 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." 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 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 the notable advances in DSNY's clean diesel fleet, and provides information regarding DSNY efforts to further incorporate alternative fuel vehicles into its fleet. "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]

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

[2] This pilot was required by LL38/2005. Id.

[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).

I. 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 USEPA proposed a new, more restrictive annual standard for $PM_{2.5}$ in June 2012, which took effect in December 2012. The new annual standard declined from 15 micrograms per cubic meter to 12 micrograms per cubic meter. Based on 2014-2017 measurements, New York City's air meets the new 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 standard. In October 2015, USEPA strengthened the annual standard for ozone. The new 8-hour primary standard for ozone declined 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.

II. Dramatic Improvements in DSNY's Fleet Emissions

DSNY's fleet is achieving greater than *90% reduction in PM and 88% 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.[6] DSNY's fleet has cut annual diesel fuel use by 5.4% on average since 2005 levels. In addition, DSNY has cut its light duty fleet gasoline use by 47% since 2005.

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

Currently all of 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. DSNY has gone even further: its 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 are now taking place nationwide. This 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 advanced environmentally friendly 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.

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[5] The annual $PM_{2.5}$ NAAQS is the 3-year average annual mean concentration.
[6] For NOx, DSNY collection trucks have now achieved an 88% reduction and street sweepers have achieved a 95% reduction from their respective 2005 levels.

- 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 model year limit of 0.1 g/bhp-hr*.[7] As of 2010 NOx is limited to 0.2 g/bhp-hr, compared to 2.0 g/bhp-hr in the 2006 model year and 4.0 g/bhp-hr in the 2003 model year. 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. According to LL 73/2013, 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 has exceeded this target. Including both factory-installed equipment and retrofits, as of January 1, 2018, more than 95% of DSNY's entire on-road diesel fleet was so equipped.

B. Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions from human activities are building up in the atmosphere where they contribute to climate change. 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 model year (MY) 2017 over the 2010 baselines. Phase 2 regulations, published in 2016, apply to MY 2021-2027 vehicles.

In FY2018, DSNY ordered 446 new collection trucks for delivery in CY2018. The 446 new collection trucks will be in full compliance with EPA Phase-1 GHG standards. The new trucks will augment DSNY's fleet of environmentally friendly collection trucks and aid DSNY in complying with NYC's OneNYC GHG reduction goals of 50% by 2035 and 80% by 2050, measured against the 2005 baseline.

[7] 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 model years.

[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.

III. Alternative Fuel Vehicles

Despite the clear success of DSNY's Clean Diesel Program in minimizing fleet emissions, DSNY believes 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 763 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.

A. Light-Duty Vehicles

DSNY's light duty fleet currently includes 736 advanced low- or zero-emission vehicles, such as hybrid-electric, plug-in hybrid-electric, and electric vehicles. Hybrid-electric vehicles operate on gasoline assisted by battery technology; electric vehicles 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.

1. Hybrid-Electric Vehicles

DSNY currently owns and operates 624 hybrid-electric vehicles, such as Ford Fusion[9] and Escape, and Toyota Prius. In FY2018, DSNY will take delivery of 76 Toyota RAV4 hybrid-electric vehicles.

2. Plug-In Hybrid-Electric Vehicles

DSNY currently owns and operates 92 plug-in hybrid–electric vehicles, 17 of which are Chevrolet Volt sedans and 75 of which are Ford Fusion Energi Plug-in Hybrids. The Chevrolet Volt sedans are capable of running entirely on battery power for an extended range of up to 40 miles before a gasoline engine starts up to charge the battery.[10] Ford Fusion Energi Plug-in Hybrids are capable of running entirely on battery power for an extended range of up to 19 miles before a gasoline engine starts up to charge the battery. In FY2018, DSNY will take delivery of 13 additional Ford Fusion Energi plug-in hybrid-electric vehicles.

3. Plug-in Hybrid vs. Conventional Hybrid

The Ford Fusion Energi Plug-in Hybrid is now a commercially available model with the same California Air Resources Board (CARB) emissions rating (Alternate Technology Partial

[9] EPA mileage estimates for the Fusion Hybrid MY2014 are 41 mpg highway and 44 mpg city.
[10] Newer Chevrolet Volts (2018) can run on battery power alone for up to 53 miles.

Zero Emission Vehicle, or AT-PZEV) as the Chevrolet Volt and the Toyota Prius. As such, the Fusion Energi Plug-in Hybrid, the Volt and the Prius are capable of zero emissions when running only on battery power, but the Toyota Prius battery-only range is rated by the USEPA at under one mile.[11] In practice, a Toyota Prius will utilize its internal combustion engine and have higher direct emissions than a Fusion Energi Plug-in Hybrid or a Volt for a DSNY shift that does not exceed 19 miles of driving.

The Ford Fusion Energi Plug-in Hybrids and Chevrolet Volts have performed well in the field. The primary advantage of the Fusion Energi Plug-in Hybrid and Volt over a conventional hybrid such as the Toyota Prius or Ford Fusion Hybrid is their ability to run on pure electric battery mode for an extended range, therefore emitting fewer direct air emissions during a typical duty cycle than a conventional hybrid. According to the USEPA, a 2014 and 2015 Fusion Energi Plug-in Hybrid gets the equivalent of 88 miles per gallon when operating in all-electric mode (MPGe), and 38 mpg when operating in gasoline mode. The USEPA rated the 2011 Volt as capable of being driven an estimated 35 miles in all-electric mode; the 2017 Volt is rated for 106 MPGe in all-electric mode. The USEPA rated the 2011 Toyota Prius as achieving 50 mpg combined/51 mpg City/48 mpg highway; the 2017 Prius is rated for 52 mpg combined/54 mpg City/50 mpg highway.[12] 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.

Ford Fusion Energi Plug-in Hybrids (at $30,680) or Chevrolet Volts (at $33,220)[13] would cost the City significantly more than a Toyota Prius (at $21,862), 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 per Fusion Energi Plug-in Hybrid for the first 200,000 vehicles sold. Accordingly, 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 Prius that is driven 10,000 miles annually (the average for a DSNY sedan) for 8 years (the useful vehicle life for a DSNY sedan) will require 192 gallons of gasoline per year at a cost of $1.88 per gallon as of January 2018, for a total of $2,888 in fuel costs (excluding oil changes, etc). A Fusion Energi Plug-in Hybrid that is driven the same daily distances in pure electric mode (by not exceeding 19 miles per driving cycle) would in theory require no gasoline over the 8 years, and save much of the $2,888, minus the cost of electricity consumed (0.36 kWh/mile at $0.145/kWh), which comes to approximately $522, well under the equivalent cost of gasoline. Even so, however, over this period the Fusion Energi Plug-in Hybrid's savings in fuel would not compensate for the higher initial cost of the Fusion Energi Plug-in Hybrid, absent subsidies.

In determining which light-duty vehicles to purchase, DSNY evaluated the operational performance of the Fusion Energi Plug-In Hybrid and Volt and conventional Prius and Fusion Hybrids together with environmental considerations. DSNY has observed no significant difference in performance in the field between the Fusion Energi Plug-in Hybrid,

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[11] On average, a DSNY sedan travels approximately 33 miles in a day.

[12] The 2011 Toyota Prius remained essentially unchanged until the recently released 2016 model.

[13] The price is the 2017 MSRP, which decreased by $5,000 since FY2013. The Volt was not included in the City's FY2014, FY2015, FY2016, or FY2017 contracts.

the Volt, the Prius 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 requirement of charging the Fusion Energi Plug-in Hybrid and Volt creates certain operational issues not posed by the Prius or Fusion Hybrid, including a comparatively long charge time (about three hours at 240V), 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 and Volt is inadequate for the Department's 12-hour shifts during snow operations. The environmental benefits of operating a Fusion Energi Plug-in Hybrid or Volt over the Prius or Fusion Hybrid for DSNY's fleet (equivalent to 24 to 27 more mpg equivalent, with lower local emissions and lower carbon emissions) can only be obtained via an adequate infrastructure and flexibility in charging time.

The Department will continue to assess the technological advances of hybrid electric vehicles and plug-in hybrid electric vehicles.

4. *Zero-Emission Vehicles*

DSNY operates certain zero-emission all-electric vehicles in its fleet under the mandate of LL 38/2005. In CY2013, DSNY acquired 18 all-electric Nissan Leafs ($29,929) 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 the Fusion Energi Plug-in Hybrid or Volt may be insignificant however, when DSNY sedan usage stays under 19 miles per driving shift, so that the Fusion Energi Plug-in Hybrid or Volt operates primarily in electric mode, as noted above. Moreover, such all-electric vehicles 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) become 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 forced to drive passenger cars experience great difficulty navigating through heavy snow due to low ground clearance and poor traction-control of front-wheel drive passenger cars. Many DSNY passenger cars 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 his/her assigned area. In many cases, the passenger car's undercarriage (aprons, air-dams, fenders, etc.) sustains very costly and extensive damage, which can weigh heavily on the Department's budget. 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 light-duty hybrid SUVs with four-wheel drive capability in lieu of electric and/or plug-in hybrid cars (lacking such capability) for all jurisdictions responsible for snow-removal operations.

DSNY currently has 95 Level 2 electric vehicle charging stations citywide, which include a total of 137 charging ports. In CY2017, DSNY installed 37 additional Level 2 electric vehicle charging stations.

In CY2011, DSNY also purchased and is testing two Ford Transit Connects (pure plug-in electric vans). Both vehicles have been discontinued by the manufacturer. These vehicles will remain as part of DSNY's fleet until the end of their 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 sanitation vehicles into its fleet.

B. Heavy-Duty Vehicles

1. Compressed Natural Gas (CNG)

DSNY currently owns and operates 39 dedicated CNG collection trucks in its heavy-duty fleet. DSNY has no CNG street sweepers or light-duty CNG vehicles in its fleet.

2. CNG Street Sweepers

As explained in prior annual reports, DSNY has discontinued the evaluation pilot study of CNG sweepers. Starting in 2007, DSNY performed evaluations and assessments on the operation and reliability of CNG street sweepers versus conventional clean diesel street sweepers equipped with BART pursuant to local law. Based on the results, clean diesel street sweepers with BART are more reliable than CNG sweepers. As discussed below, CNG sweepers tested did not offer a significant emissions advantage over new Clean Diesel sweepers. Furthermore, in the late fourth quarter of 2009, Cummins announced that it would no longer offer the current CNG engine for street sweepers because it does not meet the USEPA 2010 air emission standard for NOx. No other manufacturer made a CNG engine of the size needed for DSNY's street sweepers. As DSNY had no viable option for new CNG street sweepers, DSNY ended the evaluation pilot study of CNG sweepers. All of the CNG sweepers in the DSNY fleet have reached the end of their operational life (five years) and therefore have been relinquished.

In Calendar Year 2016, Cummins released a 6.7 Liter CNG engine (ISB Gas). This engine is applicable to the CNG street sweeper and is engineered to the sweeper and available as of late 2016. At this time, DSNY has no plans to purchase additional CNG sweepers.

3. CNG Collection Trucks

DSNY currently owns and operates 39 dedicated CNG sanitation collection trucks (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 put these 23 additional trucks into service in January 2014.

4. Hybrid-Hydraulic CNG Collection Truck

In an agreement with National Grid, DSNY also put into service one hybrid-hydraulic CNG collection truck in October 2010. The reliability of this truck has been acceptable. Because the manufacturer can no longer support this first-generation design, the hybrid-hydraulic technology had to be disabled and the truck is currently in service as a CNG collection truck (see Appendix 1).

5. CNG Fueling Facility

Under a federal consent order, DSNY built a fully-operational, heavy-duty vehicle CNG fueling station in Woodside, Queens, at a cost of approximately $2,950,000.[14] This station went into service in May 2007 and provides shorter fueling times than other CNG fueling facilities. This is DSNY's only CNG fueling facility.

6. Discussion: CNG vs. Clean Diesel

From an operational perspective, preliminary 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.[15] 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.[16] It has been noted that CNG trucks are somewhat quieter than diesel trucks,[17] 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 below current diesel prices and may offer stability advantages. As of January 10, 2018, a gallon of diesel fuel cost $2.65 while a gallon-equivalent of CNG cost approximately $2.58; whereas one year earlier in January 2017, a gallon of diesel fuel

[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.).
[15] 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).
[16] Peter Hildebrandt, "NGVs & Onboard Equipment," *MSW Management*, March/April 2011, *NGV Fleet Manager Supplement*, at 14 (citing figures from Clean Vehicle Education Foundation).
[17] INFORM, Inc., *Greening Garbage Trucks: New Technologies for Cleaner Air* (2003).

cost \$2.36 while a gallon- equivalent of CNG cost approximately \$2.57. CNG-fueled vehicles have lower fuel efficiency and a CNG-fueled collection truck costs approximately \$36,087 more per unit than a diesel collection truck. 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 \$2.65/gal is \$7,314 (versus last year's annual cost of \$6,514); the equivalent in CNG fuel at \$2.58/gal eq. is \$7,121 (versus last year's annual cost of \$7,093). Further, DSNY has only one CNG fueling station for its 59 district garages, 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 in capital funds to build CNG fueling infrastructure and in facility modifications as required by the New York City Building Code.

In October 2015, Cummins announced that the 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. From an air emissions/public health perspective, only the recently introduced Cummins ISL GNZ CNG engine offers a significant advantage over clean diesel in terms of its 90% NOx emissions reduction. At this time, DSNY plans to purchase 6 new Mack Trucks powered by the Cummins ISL GNZ CNG engine for its fleet in FY2018.

Hybrid-Electric Heavy Duty Vehicles

7. *Hybrid-Electric Sweepers*

DSNY is currently testing 14 diesel-powered hybrid-electric street sweepers in eight districts (see Appendix 2). In CY2010, DSNY put into service the world's first Class-7 hybrid-electric street sweeper. In CY2013 and CY2014, DSNY increased its fleet of diesel powered hybrid-electric street sweepers to fourteen; however, one was condemned in 2015. In CY 2016, two diesel-powered hybrid-electric street sweepers were condemned. In FY2016, DSNY purchased seven additional diesel-powered hybrid-electric street sweepers that were put into service in CY2017. DSNY plans to purchase an additional seven diesel-powered hybrid-electric street sweepers in FY2018. Preliminary test results indicate that these hybrid-electric 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.

8. *Hybrid-Electric Diesel Collection Trucks*

In CY2017, DSNY's three experimental (prototype) hybrid-electric diesel trucks from Crane Carrier Corporation reached the end of their useful life. This initiative was sponsored by the New York State Energy Research and Development Authority and the Hybrid Truck Users Forum. This hybrid technology has the potential to reduce fuel use and related emissions by capturing and reusing energy that is otherwise wasted during the frequent braking of collection vehicles. Test results indicate that these hybrid-electric (HEV) diesel collection trucks are approximately 10% more fuel efficient than a non-hybrid counterpart. However, after evaluating the technology, DSNY determined that due to the low-speed of its collection trucks, DSNY is unable to take advantage of the full potential of this technology because of the low energy capture rate. Hybrid technology is designed to capture kinetic energy, store it, and use it to offset the amount of diesel fuel needed to propel the vehicle (Hydrostatic Regenerative Braking (HRB) System). For regenerative braking to be effective, the vehicle must be moving with an average speed greater than 20 mph. This is very challenging for DSNY's collection truck fleet where the average speed is less than 10 mph, which prevents DSNY from taking full advantage of the benefits of regenerative braking. Furthermore, an HEV option is cost prohibitive and currently not available from DSNY's current suppliers due to a drop in demand.

Hybrid-Hydraulic Heavy Duty Vehicles

9. *Hybrid-Hydraulic Diesel Collection Trucks*

2017 Update. 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 in the last year, 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 47 hybrid-hydraulic collection trucks in the fleet will continue in service until they reach the end of their operational life.

Background. DSNY ordered two experimental (prototype) hybrid-hydraulic diesel trucks from Crane Carrier Corporation in 2008, which were put into service in October 2009 (see Appendix 3). 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 are 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 47 hybrid-hydraulic diesel trucks in service. As noted above, this hybrid technology has the potential to reduce fuel use and related emissions by capturing and reusing energy that is otherwise wasted during the frequent braking of collection vehicles.

The hybrid-hydraulic diesel collection trucks generally outperformed the hybrid-electric diesel collection trucks, with less downtime. DSNY's testing of this first generation hybrid-hydraulic technology indicated a fuel savings of approximately 10%, a corresponding reduction in pollutants and GHG emissions and a savings in brake replacement frequency and associated labor. DSNY mechanics are already familiar with servicing hydraulic technology from standard rear-loading collection trucks that have hydraulic compaction systems, which help minimize retraining needed for the new technology. The trucks were also found to result in less braking "squeal" noise than from conventional diesel collection trucks. Following successful testing in 10 European cities and New York City, the manufacturer put the hybrid-hydraulic technology into mass production in October 2010. As a result, the incremental additional cost of hybrid-hydraulic technology dropped to $47,000 when applied to a diesel truck, compared to an increment of $36,087 for CNG trucks. Thus, 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

$2.65/gal is $7,314; a 10% savings in fuel amounts to approximately $731/year compared to a conventional clean diesel collection truck, assuming stable fuel costs.

C. Dimethyl Ether (DME)

In January 2017, DSNY partnered with Oberon Fuels and Mack Trucks to test the performance of the first pre-production DME-powered Mack tractor truck. DME is a non-toxic, clean-burning alternative fuel and generates no soot. The fuel offers many benefits, including reduction of GHG emissions when it is produced from organic waste. The three-month pilot took place on Staten Island. DSNY was honored to be the first fleet in North America to test the DME-powered Mack truck. The performance of the DME-powered truck was satisfactory. DSNY looks forward to any future opportunities to advance the testing of DME fuel.

D. 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 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.[18] 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.

According to LL 73/2013, for fiscal year beginning July 1, 2016, all diesel fuel-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. Previously, in August 2007, DSNY implemented its B20 pilot study in the Queens District 6 and based on those encouraging results, in July 2010 DSNY expanded the study to the Brooklyn District 5. In advance of the LL 73/2013 mandate beginning July 1, 2016, DSNY expanded the pilot study citywide in CY 2013, for a total of 59 districts. Testing in all districts is on-going, but results have been promising. B5 biodiesel costs about the same as standard ULSD, while B20 biodiesel costs approximately $0.04 more per gallon. DSNY plans to use B20 generally from April 1 through November 1 and B5 during the remainder of the year (colder weather). In FY 2017 DSNY used 10,382,020 gallons of diesel of various blends, of which 61% was B20 biodiesel and 39% was B5 biodiesel. The use of these grades of biodiesel reduced GHG emissions from the fleet in 2017 by 16,017 metric tons of CO_2, from the FY2005 baseline fleet GHG emissions from diesel, a 15% reduction. Using B20 yielded a net reduction in carbon emissions of approximately 20% compared to conventional fossil fuel diesel use.[19] To date, DSNY has displaced well over

[18] 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.

[19] To date, since 2006 DSNY's use of B20 has resulted in the saving of approximately 110,000,000 pounds of CO_2.emissions.

eight 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.

As per LL 73/2013, on December 1, 2016, DSNY commenced a B20 Winter Pilot (utilizing B20 during the winter) at seven district locations. In CY2017, DSNY expanded the pilot to seven additional district locations. The 14 district locations are:

1. *Manhattan 4*
2. *Manhattan 9*
3. *Manhattan 10*
4. *Manhattan 11*
5. *Brooklyn 5*
6. *Brooklyn 16*
7. *Brooklyn 10*
8. *Brooklyn 18*
9. *Queens 4*
10. *Queens 6*
11. *Queens 8*
12. *Queens 12*
13. *Staten Island 1*
14. *Staten Island 3*

DSNY will prepare a detailed report when the B20 winter pilot is completed.

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 CO_2. 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.

The NYC Clean Fleet Plan 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 Plan will be highlighted by a number of key steps including, but not limited to:

- Replace approximately 2,000 fossil fuel sedans with plug-in electric vehicles,
- Expand the use of anti-idling, hybrid, and stop-start technologies in medium- and heavy-duty vehicles,
- Increase the use of alternatives to traditional diesel fuels, including higher biodiesel blends, and 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

CNG and other alternative fuel collection trucks to assess their respective environmental and economic performances. DSNY’s B20 initiative citywide has met with positive results and testing is ongoing. This initiative has the potential to further reduce truck emissions, including greenhouse gases. DSNY is committed to achieving the goals of the NYC Clean Fleet Plan and sustainable fleet GHG reduction.

* * *

Appendix 1: DSNY's CNG Collection Trucks

Vehicle ID	Make / Model	Vehicle Type	VIN #
25CNG-503	Crane Carrier LET2	Rear Loading	1CYCCZ4828T048570
25CNG-505	Crane Carrier LET2	Rear Loading	1CYCCZ4868T048572
25CNG-506	Crane Carrier LET2	Rear Loading	1CYCCZ4888T048573
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-607	Crane Carrier LET2	Rear Loading	1CYCCZ4879T049425
25CNG-608	Crane Carrier LET2	Rear Loading	1CYCCZ4899T049426
25CNG-609	Crane Carrier LET2	Rear Loading	1CYCCZ4809T049427
25CNG-701	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001603
25CNG-702	Crane Carrier LET2	Rear Loading	1M2AU14C6DM001604
25CNG-703	Crane Carrier LET2	Rear Loading	1M2AU14C8DM001605
25CNG-721	Crane Carrier LET2	Rear Loading	1M2AU14C9DM001709
25CNG-722	Crane Carrier LET2	Rear Loading	1M2AU14C5DM001710
25CNG-723	Crane Carrier LET2	Rear Loading	1M2AU14C7DM001711
25CNG-724	Crane Carrier LET2	Rear Loading	1M2AU14C9DM001712
25CNG-725	Crane Carrier LET2	Rear Loading	1M2AU14C0DM001713
25CNG-726	Crane Carrier LET2	Rear Loading	1M2AU14C2DM001714
25CNG-727	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001715
25CNG-728	Crane Carrier LET2	Rear Loading	1M2AU14C6DM001716
25CNG-729	Crane Carrier LET2	Rear Loading	1M2AU14C8DM001717
25CNG-730	Crane Carrier LET2	Rear Loading	1M2AU14CXDM001718
25CNG-731	Crane Carrier LET2	Rear Loading	1M2AU14C9DM001726
25CNG-732	Crane Carrier LET2	Rear Loading	1M2AU14C0DM001727
25CNG-733	Crane Carrier LET2	Rear Loading	1M2AU14C2DM001728
25CNG-734	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001729
25CNG-735	Crane Carrier LET2	Rear Loading	1M2AU14C0DM001730
25CNG-736	Crane Carrier LET2	Rear Loading	1M2AU14C2DM001731
25CNG-737	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001732
25CNG-738	Crane Carrier LET2	Rear Loading	1M2AU14C6DM001733
25CNG-739	Crane Carrier LET2	Rear Loading	1M2AU14C8DM001734
25CNG-740	Crane Carrier LET2	Rear Loading	1M2AU14CXDM001735

Appendix 2: DSNY's Hybrid-Electric Street Sweepers

Vehicle ID	Make	Vehicle Type	VIN #
20XE-204	Global Environmental Products	Street Sweeper	2A9AM4LL0BB181208
20XE-301	Global Environmental Products	Street Sweeper	1G9GH4LM1ES462002
20XE-302	Global Environmental Products	Street Sweeper	1G9GH4LMXES462001
20XE-303	Global Environmental Products	Street Sweeper	1G9GH4LM8FS462001
20XE-304	Global Environmental Products	Street Sweeper	1G9GH4LMXFS462002
20XE-305	Global Environmental Products	Street Sweeper	1G9GH4LM1FS462003
20XE-306	Global Environmental Products	Street Sweeper	1G9GH4LM3FS462004
20XE-307	Global Environmental Products	Street Sweeper	1G9GH4LM5FS462005
20XF-001	Global Environmental Products	Street Sweeper	1G9GM4LM1HS462002
20XF-002	Global Environmental Products	Street Sweeper	1G9GM4LM3HS462003
20XF-003	Global Environmental Products	Street Sweeper	1G9GM4LM5HS462004
20XF-004	Global Environmental Products	Street Sweeper	1G9GM4LM7HS462005
20XF-005	Global Environmental Products	Street Sweeper	1G9GM4LM9HS462006
20XF-006	Global Environmental Products	Street Sweeper	1G9GM4LMXHS462001

Appendix 3: DSNY's Hybrid Collection Trucks

Chassis Mfg	Fuel	Hybrid Sys	Series/Parallel	# of Units in Service
Mack	Diesel	Hydraulic	Parallel	47