Ending the Diesel Era

Cleaner Fleets for a Healthier New York City

A Report by Energy Vision

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ENERGY VISION

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Energy Vision is a national 501 (c) (3) organization based in New York City whose goal is to promote—through research and action—a swift transition to zero- and near-zero emission renewable energy and fuel options. Energy Vision informs and engages with policy, business, and environmental leaders, to support the shift of medium- and heavy-duty bus and truck fleets along the path toward a sustainable transportation future.

This report was prepared by Energy Vision's core team and advisors, with major contributions from Matthew P. Tomich, Phil Vos and Joanna D. Underwood.

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Foreword

As Commissioner of Sanitation for New York City in the late 1980's, I was very proud of the Department and our work. But I was embarrassed when I ran into demonstrators in City Hall Park who were protesting our trucks for their relationship to *asthma!* I had not heard about this before. So I decided to study it. I learned that asthma is a major killer of children—especially urban, poor children—and while asthma causation is still partly a mystery, diesel exhaust is one of the well-established asthma triggers.

I was horrified to learn that while we were proud to be cleaning the City's streets in its many neighborhoods, we also were dirtying the air. This led to DSNY trying out the first natural gas trucks and street sweepers in the country. They were much cleaner (and mercifully quieter). But the early technology was new and did not operate to our standards, especially for plowing snow.

Today, after two decades of development, not only do natural gas engines work as well or even better than diesel models, but they can take advantage of a fuel even better than conventional natural gas. That is the renewable, non-fossil, non-fracked form of natural gas requiring no drilling and made from organic waste called "biomethane" or "Renewable Natural Gas (RNG)."

While diesel engines long had the benefits of power and fuel use efficiency, I am now convinced that they are an outmoded choice. New natural gas heavy-duty engines have the power to do what NYC trucks need to do—collect garbage and plow snow—with less noise and much less pollution or carbon impact. Smog forming nitrogen oxides and particulates—the pollution most linked to asthma and other lung problems—are especially lower with these engines.

It is time for New York's fleets, especially its huge refuse fleet, to start aggressively phasing out diesel as many other cities and private haulers across the country are doing. *More than half the refuse trucks on order today are for natural gas models—it is now an established technology.* A quarter of the transit buses are as well. And some fleets are also experimenting with electric battery technology and "renewable diesel."

While natural gas engines burning RNG fuel are the most widely successful today, whatever zero or near-zero emission technology and fuel choices emerge going forward for specific truck and bus types, diesel no longer deserves to be the default choice in New York or other crowded cities.

This new Energy Vision report lays out the ambitious plans New York City has made to reduce the greenhouse gases and air pollution generated by city truck fleets and shows clearly the contribution a diesel phase-out strategy can make—putting NYC right at the leading edge of sustainable heavy-duty transport. It should be a valuable resource to City leaders in charting its course.

Brendan Sexton
Environmental Consultant
Former Commissioner of Sanitation for New York City

Introduction: New York City's Clean Air and Climate Change Challenge

The lifeblood of New York City—and cities across the country—is our workhorse truck and bus fleets. They transport people, deliver goods to homes and stores, keep our streets clean by collecting our garbage and recyclables, tend to our parks, repair our utility infrastructures, and so much more. Urban life and commerce could not go on without these service vehicles.

Diesel Fuel and Human Health: Because virtually all these buses and trucks run on diesel fuel, they have also contaminated the air we breathe and exposed millions of New Yorkers to particulate and nitrogen oxide emissions that choke lungs, trigger asthma attacks and damage cardiovascular systems. The workers who rightly take pride in providing these essential urban services are among those who often pay the highest price, as a result of prolonged exposure to diesel fumes and the noise of diesel engines.

These health threats are significant. Many studies in the US and Europe have documented the numerous health risks caused by diesel emissions.[1] New research published in 2018 concludes that even brief exposure to elevated levels of fine particulate matter ($PM_{2.5}$) can have profound negative impacts, especially on children.[2]

In a new authoritative book, *Children and Environmental Toxins*, Dr. Philip J. Landrigan, Dean for Global Health, Professor of Environmental Medicine, Public Health and Pediatrics at Mount Sinai Hospital, and a leading expert on the effects of pollution writes: "Diesel exhaust contains dirtier and more toxic fumes than gasoline exhaust. It is comprised of soot, carbon dioxide, carbon monoxide, several oxides of nitrogen and sulfur, formaldehyde and benzophrene. One of the most toxic components of diesel exhaust is 1,3 butadiene, a powerful carcinogen. Diesel exhaust has been classified as a known human carcinogen." Dr. Landrigan has summarized the health impacts of diesel emissions: *"The air pollution produced by diesel exhaust contains potent respiratory irri-tants, metabolic toxins and proven human carcinogens. Diesel exhaust is a known cause of asthma, cardiovascular disease, stroke and lung cancer."*

Asthma-related hospital visits in NYC are more than 8 times higher in poor communities; see p. 9. (Source: Sam Hodgson for Reveal News)

In New York City, 173,600 children—an astonishing 13.3% of the total—suffer from asthma (compared to a national average for children up to 18 years of 8.3%[3]). It is the leading cause of in-patient hospital stays for children. The rates of hospitalizations are highest in poorer areas (the Bronx, East and Central Harlem, Central Brooklyn) and disproportionately affects children of color; 22% of black children, 15% of latino children and 4% of white children.[4]

Diesel and Climate Change: Not only is our urban air quality degraded by diesel exhaust, but so is the stability of our global climate. High-carbon diesel fuel—even when blended as biodiesel—emits approximately 22 pounds of climate warming greenhouse gases per gallon, including carbon dioxide (CO_2) and nitrogen oxides (NOx). Diesel exhaust is also a major source of black carbon, which is recognized by the international scientific community as a major but short-lived climate pollutant. Reducing emissions of these pollutants would have significant and immediate positive environmental and public health impacts.[5]

In 2012, the impact of climate change first hit New York directly. Superstorm Sandy wreaked $32 billion in damage, with thousands of homes and businesses destroyed, 250,000 vehicles wrecked and more then 50 lives lost. (Source: Anton Oppan)

New York and cities around the world are grappling today with how to sustain the vital truck and bus fleet services on which much of their public transport, essential municipal services and commerce depend, while ending the damage the diesel era has inflicted.

Ending the Diesel Era: A Search for Solutions

This report focuses on what New York City can do and the bold plans it has made. The City's leaders deserve credit, not only for setting ambitious greenhouse gas reduction and clean air goals, but also for the City's progress in moving toward them. However, based on Energy Vision's analysis, the City's plans may fall short of reaching its goals.

This report examines the key limitation Energy Vision has found in the City's approach: the failure to pursue the phase-out in the use of diesel fuel in its 10,000 medium- and heavy-duty vehicles. Such a phase-out would enable the City not only to meet but even to exceed the goals it has set. By committing to "No More Diesel," both the City fleets and the MTA bus fleet would dramatically reduce diesel exhaust and its harmful impacts.

Proven and commercial zero- and near-zero-emission technologies exist today for various uses, though they differ in vehicle, fuel and/or maintenance costs. They include battery electric, now being tested by MTA buses, compressed natural gas (proven and in use now in some buses and trucks), and one strategy barely mentioned in the 2015 *NYC Clean Fleet* plan: the use of the renewable form of natural gas fuel made from organic waste.

Yet Renewable Natural Gas (RNG) is the most promising technology available today. Production of renewable natural gas, also called "biomethane", requires no drilling because it is made by capturing and refining the methane biogases emitted by decomposing organic wastes. It is a commercial choice; it is affordable; it cuts health-threatening NOx and PM emissions close to zero when used in EPA-certified "Near Zero" engines, and it is the lowest carbon of any fuel on a lifecycle basis. Today 20,000 refuse trucks and buses run on RNG across the country (although none are in NYC). While the logistics of change are always challenging, such as modifications in infrastructure, equipment and operations, it is essential to weigh all the options and put the best ones to use.

Transitioning to zero- or near-zero-emission heavy-duty vehicles across the City's fleet would enable a complete shift away from diesel in fewer than 15 years. The Department of Sanitation (DSNY), for example, operates the City's largest heavy-duty fleet and buys several hundred new trucks each year, producing a total turnover of its fleet in seven or eight years. Every fleet with heavy-duty vehicles—at the Department of Parks, Transportation, Department of Environmental Protection, etc.—has its own vehicle replacement schedule. Launching this shift could begin immediately in select locations across New York City where air quality is poorest.

There is a strong economic case for this transition. While battery electric vehicles cost $200,000 or more over the cost of diesel vehicles, heavy-duty trucks equipped with near-zero natural gas engines are just $50,000 more than comparable diesel models. Combined with lower fuel and operating costs, the incremental expenditures can more than pay for themselves over the life of the vehicle, especially in heavy fuel-consuming fleets. Further, many private sector companies are eager to expand the necessary non-diesel refueling infrastructure, whether it's recharging stations, natural gas refueling facilities, or maintenance garage modifications. At just a fraction of the approximately $6 billion the City estimated that it would spend by 2035 in achieving its *Clean Fleet* goals (outlined in its December 2015 Clean Fleet RFI), near-zero emissions trucks could be deployed citywide.

New York City has signaled its intent to move away from fossil fuels by pursuing divestment from companies active in extractive industries in its pension funds. Yet its annual budget still dedicates hundreds of millions of dollars to procuring diesel vehicles, fuel, and related infrastructure. The City could dedicate some of its fleet and fuel procurement funds to buying zero- or near-zero-emission non-diesel vehicles. This would be a powerful and direct way for the City to align its buying power with its goals.

Such a phase-out has been successful in other cities: London has banned the purchase of new diesel vehicles in its municipal fleets and is replacing old vehicles with non-polluting alternatives. Other cities around the world—from Oslo and Rome to Beijing and Shanghai—have passed legislation restricting the use of diesel vehicles, citing the fuel's negative impacts on air quality and climate.

"Replacing diesel vehicles with safer, non-polluting alternatives will reduce rates of asthma among our children," writes Mt. Sinai's Dr. Landrigan. *"It will reduce myocardial infarctions, cardiac arrhythmias, and strokes among New York City's adults. It will reduce the risk of lung cancer. And because it will prevent many cases of these debilitating diseases, the elimination of diesel trucks and buses from the vehicle fleets in New York will reduce health care costs and save money."*

As both the largest city in the country and one of the wealthiest on the planet, New York has the means and opportunity to invest in zero- and near-zero-emission vehicles today for its fleets—that would assure steady and essential progress toward the vital goals that the City's leaders have and that our world urgently needs.

Greenhouse Gas Reduction and Clean Air Goals for NYC Fleets

New York City has set ambitious goals, including delivering healthy air to its more than eight million residents, doing its share in addressing the global challenge of climate change, eliminating landfill wastes and ending the city's reliance on fossil fuels.

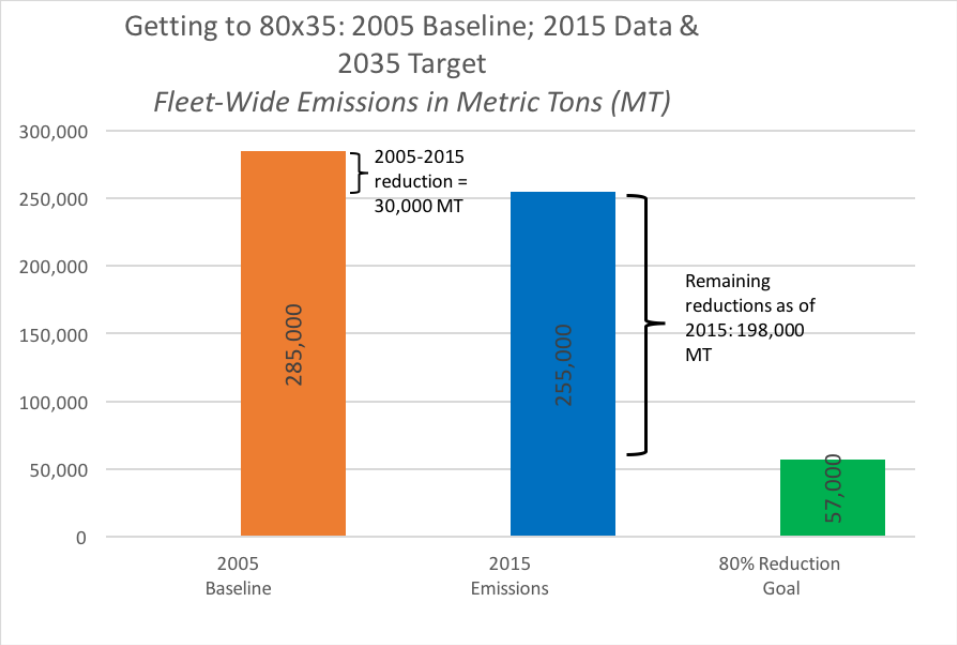
Recognizing climate change to be "an existential threat to New Yorkers and the world," New York City has set a goal of cutting its greenhouse gas emissions 80% by 2050 (against a 2005 baseline), in line with the 2015 Paris Climate Accord. But NYC has included an ambitious goal of cutting these emissions from its own vehicle fleets by 80% even sooner—by 2035. The City's OneNYC *Plan aims to achieve the best air quality of any major American city by 2050, and also to send zero waste to landfills by 2030.*

Greenhouse Gas Reduction Goal and Strategies: The *NYC Clean Fleet* plan identifies specific strategies for achieving emissions reductions for its roughly 17,000 light-duty vehicles; some of those strategies also apply to heavier vehicles. The plan identifies three broad options for the roughly 10,000 medium- and heavy-duty diesel-fueled vehicles that are operated mostly by the Department of Sanitation, Parks Department, NYC Department of Environmental Protection, Fire Department of New York and Department of Transportation.[6]

Looking first at its greenhouse gas reduction goal: in setting the City's 80 x 35 vehicle GHG reduction target, the *NYC Clean Fleet* plan works from a baseline of 2005 emissions of 285,000 metric tons a year. Therefore, to achieve an 80% GHG reduction goal by 2035, total annual fleet-wide emissions must be at or below 57,000 metric tons—a total reduction of 228,000 metric tons.[7]

Taking reductions since 2005 into account, *NYC Clean Fleet* puts 2015 emissions from the 27,000 fuel-burning vehicles in City fleets at 255,000 metric tons, or a reduction of 30,000 metric tons over 10 years. This means emissions must still be cut by an additional 198,000 metric tons of carbon-dioxide equivalent ("CO2e")—a cut of 77% from 2015 levels.[8]

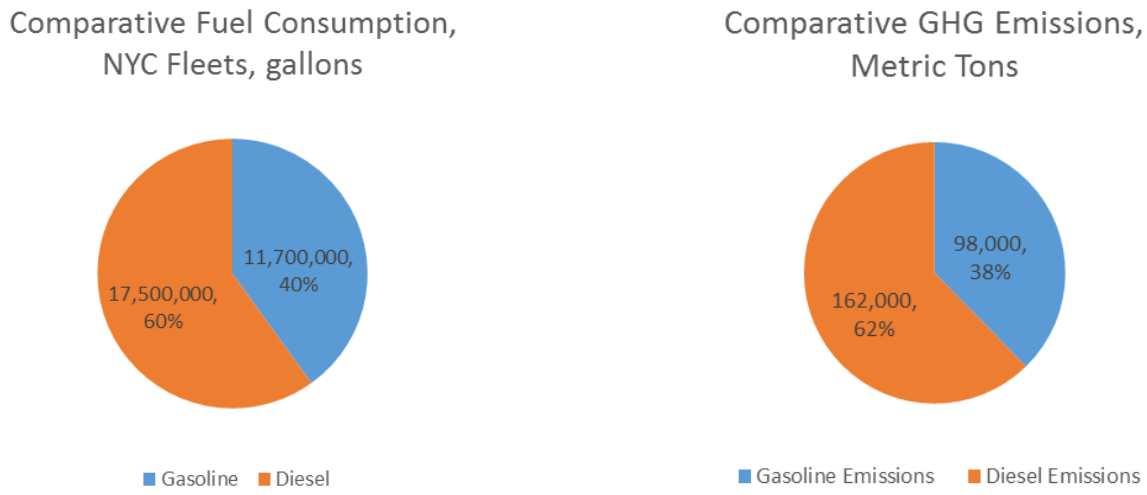
Figure 1. ***Cutting Greenhouse Gases 80% by 2035: 2005 Baseline; 2015 Progress; 2035 Target***



Energy Vision calculations, based on NYC Clean Fleet

At the time of the 2015 report, 40% of total fleet fuel was gasoline (11.7 million gallons),[9] used primarily in light-duty vehicles, with related emissions of about 98,000 metric tons of CO2e.[10] The other 60% of fuel was diesel blends (17.5 million gallons) used in medium- and heavy-duty vehicles with related emissions of 162,000 metric tons of CO2e[11]. With diesel vehicles responsible for this large share of GHG emissions (62%), reaching the "80 x 35" goal will require significant diesel displacement.[12]

Figure 2. ***Fuel Consumption and Greenhouse Gas Emissions from NYC's Diesel Truck Fleets Compared to its Gasoline-Fueled Light-Duty Fleets***



Derived from NYC Clean Fleet and the Inventory of NYC Greenhouse Gas Emissions in 2015

Limitations in the City's Plan to Reach its Greenhouse Gas Reduction Goal

The *NYC Clean Fleet* plan includes four strategies to be implemented fleet-wide (see table below). It sets a specific goal for its light-duty vehicles—adding 2,000 electric vehicles (EVs) by 2025, of which 1,200 are already in operation. The plan also designates two specific fuel efficiency goals and a specific anti-idling goal. Combined with emissions reductions achieved between 2005 and 2011 (11%), all of these fleet-wide strategies would achieve a 44% reduction in fleet-wide emissions.

Table 1. ***The NYC Clean Fleet Plan's Four Emission Reduction Strategies IF applied to all City Vehicles ("whole-fleet measures"), and their Impact on GHG Emissions***

Measures	GHG reduction (%)	GHG reduction (metric tons)	GHG reduction remaining (%)	GHG reduction remaining (metric tons)
Emissions reductions achieved 2005-2011	11%	30,000	69%	198,000
Whole-fleet 1: Add 2,000 electric vehicles	9%	25,650	60%	172,350
Whole-fleet 2: Meet EPA 2018 fuel economy standards for medium and heavy duty vehicles	10%	28,500	50%	143,850
Whole-fleet 3: Meet EPA 2025 fuel economy standards for light duty vehicles	9%	25,650	41%	118,200
Whole-fleet 4: Anti-idling & stop-start technology	5%	14,250	36%	103,950
ACHIEVED REDUCTIONS + WHOLE-FLEET, SUBTOTAL	**44%**	**124,050**	**36%**	**103,950**

Energy Vision calculations, based on NYC Clean Fleet. Percentages are calculated against 2005 baseline of 285,000 metric tons (30,000 metric tons calculated as 11% of 285,000 metric tons is taken directly from NYC Clean Fleet).

What about the rest? For medium- and heavy-duty diesel vehicles, the *NYC Clean Fleet* plan identifies three separate options:

- **Option one** involves using high biodiesel blends (20% year-round and 50% seasonally) in all these vehicles, which would cut fleet-wide GHGs 10%, bringing the total GHG reduction, when combined with the aforementioned "whole-fleet" measures, to 54%.
- **Option two** involves using high biodiesel blends in half the fleet and compressed natural gas fuel in the other half, cutting more GHGs—a total of 14%—and bringing fleet-wide GHG reductions to 58%.
- **Option three** involves using "renewable diesel fuel" in one-third of the fleet and high biodiesel blends and CNG in the remaining two-thirds, cutting GHGs by 34% and bringing the total GHG reduction up to 78% out of the 80% required by 2035.

Table 2. ***Three Diesel-Specific Emission Reduction Options, on Their Own and Combined with Achieved Reductions and "Whole-Fleet" Measures***

	Diesel Strategy 1: All vehicles on higher biodiesel blends	Diesel Strategy 2: Half fleet on higher blends, half on CNG	Diesel Strategy 3: Divide fleet between higher blends, CNG and renewable diesel
GHG reduction (%)	10%	14%	34%
GHG reduction (metric tons)	28,500	39,900	96,900
% reduction combined with achieved reductions and whole-fleet measures (44%)	54%	58%	78%
Reduction in metric tons combined with achieved reductions and whole-fleet measures (124,050)	152,550	163,950	220,950
GHG reduction remaining (%)	26%	22%	2%
GHG reduction remaining (metric tons)	75,450	64,050	7,050

Energy Vision calculations, based on NYC Clean Fleet; Percentages are calculated against 2005 baseline of 285,000 tons

The *Clean Fleet* plan's success relies heavily on the use of two diesel displacement strategies highlighted in Table 2 above—compressed natural gas and renewable diesel—but simultaneously cites considerable impediments to deploying them. First, it labels infrastructure upgrades for managing CNG (primarily ventilation in the depots) as a "formidable" obstacle. Then it notes that renewable diesel is not yet widely available in the northeastern United States and that it is unknown when it will become available.[13] Despite only regional availability, the City recently announced a 900,000 gallon renewable diesel pilot (see p. 14). Energy Vision presents below a fourth, and most immediately high-impact option for the City—one mentioned only in passing in the City's plan.

The Path for Success: Embracing the New Zero- or Near-Zero Emission Technologies

The City's diesel fleet, as noted previously, consumes 60% of the fleet fuel and generates 62% of fleet-related greenhouse gases (GHGs), making it the most important target for reducing emissions of GHGs, nitrogen oxides (NOx), and particulate matter (PM). Therefore, it is vital to clarify what is known about each option for diesel displacement: its capacity to cut greenhouse gases and health-threatening air pollutants as well as its costs and commercial availability. Each option is discussed below, and the comparisons are summarized in Figure 3 (p. 11).

Biodiesel Blends. Biodiesel blends offer only modest clean air and climate benefits compared to petroleum diesel. But this fuel, referred to by the City as an "alternative fuel," is not a true alternative. The 20% blend is still

80% petroleum-diesel, and the 50% biodiesel blend to be used in the summer months is still half conventional diesel. As indicated in Table 2 (p. 5), even if the entire diesel fleet were running on higher biodiesel blends, greenhouse gas emissions would only be cut by 10%. Biodiesel blends would not make measurable reductions in emissions of smog-forming NOx and health-threatening PM as compared to conventional diesel fuel.

Electric Vehicles. Electric vehicles—which are a true alternative—are proven at the light-duty level. However, the technology for the heavy-duty sector is still in development. The number of heavy-duty electric vehicles on our roadways nationwide—mainly buses—is only in the hundreds[14] and electric heavy-duty trucks currently lack the power and torque needed to perform adequately in NYC, especially for the largest and highest impact diesel fleet—the 2,100 refuse trucks operated by the Department of Sanitation (DSNY), which must both collect garbage and plow snow.

Electric vehicles themselves emit no greenhouse gases or air pollutants during operation. However, the lifecycle assessment of their environmental impact necessarily includes consideration of the sources of their power. Their current cost is as much as double that of conventional diesel models ($200,000 to $450,000 more than diesel), and as much as 75% more than natural gas models.[15] Nonetheless, the City would do well to explore and pilot all-electric options for the future, especially for medium-duty vehicles as well as for transit buses. (While the bus fleet is not a city-operated fleet, MTA/NYCT is now piloting ten battery electric buses.)

One of 10 all-electric buses being demonstrated by the MTA during a three-year pilot. (Source: MTA)

Compressed Natural Gas. This option—a cost-effective and proven alternative to petroleum-based diesel—is a fossil fuel, but by far the cleanest of these fuels. Purchasing these trucks instead of diesel means that they are equipped with natural gas engines instead of diesel engines. It is an option now for city trucks (as well as for MTA buses). These engines are in full commercial use after two decades of development. Their incremental cost runs from about $35,000 to $50,000 above the price of a comparable diesel model, although operating costs are often lower because the fuel requires less emissions control technology. Today, about 150,000 garbage trucks, transit buses and tractor-trailers in the US are natural gas models.[16] As the 42 CNG refuse trucks operated by DSNY have already shown, these vehicles have the power to both collect garbage and plow snow.

One of 42 CNG trucks in the DSNY fleet; able to collect garbage and plow snow. (Source: DSNY)
(The tank holding the natural gas fuel is located between the truck's cab and body.)

CNG fuel burned in new "near-zero" emission natural gas engines, which were commercialized in 2016 and certified by both the California Air Resources Board and the US EPA, cuts greenhouse gas emissions by 30% compared to diesel. But CNG fuel used in "near-zero" engines slashes health-damaging fine particulate and nitrogen oxide emissions 90% below the most stringent EPA standards. In addition, the noise levels of all natural gas engines are 50-80% lower than those of diesel engines. A shift to natural gas trucks protects the health of the communities in which they operate; it also protects the health and hearing of truck drivers and fleet maintenance officials. But unlike fleets in many other US cities, NYC fleets have purchased few of them.

Yet today, there is sufficient natural gas refueling infrastructure in NYC to serve hundreds more natural gas trucks, with seven operational stations within the five boroughs. The Department of Sanitation (DSNY) dispenses CNG from its Woodside, Queens garage (and refuels trucks at a public-access station in Greenpoint, Brooklyn), and the Department of Parks dispenses fuel from city-owned stations in Central Park and Flushing, Queens. Public-access stations also exist at LaGuardia Airport, JFK and at a National Grid location in Canarsie.

A new public-access CNG station is scheduled to open in the Bronx this spring, within three miles of six DSNY depots where dozens of trucks could readily access it. Finally, there is a CNG station located at the Covanta waste-to-energy plant in Newark, New Jersey, to which DSNY trucks make over 100 visits a day. This station was built with the encouragement of DSNY, but has never refueled a single DSNY truck. According to the NYC *Fleet Maintenance Manual*, the City already "offers contracts for fueling at… private CNG fueling sites,"[17] and other private station developers have expressed strong interest in building additional stations, but need fleet commitments to use the fuel before making these investments.

As with any technology, design, permitting, safety and other considerations must be taken into account. However, the "formidable obstacle" to expanded use of natural gas trucks referred to in the *Clean Fleet* plan—the need to modify garages with proper ventilation—has been overcome at multiple locations. There are costs associated with these changes, but there are no engineering challenges that cannot be met with current technology, as evi-denced by the four large indoor depots housing the 800-plus MTA/NYCT CNG transit buses in New York City.

Renewable Diesel. This fuel is a true alternative to petroleum-based diesel. It is a liquid fuel made from animal fats or the oils from energy crops. **In 2018,** New York City announced a 900,000 gallon pilot of renewable diesel in its existing heavy-duty fleets. Interest in this fuel (also known as synthetic or "green" diesel) arises from it being a liquid "drop-in" substitute for diesel, requiring no alterations to fuel or engine—a big logistical and economic advantage for large fleets currently using conventional diesel.

The greenhouse gas reductions from use of renewable diesel are considerable compared to use of diesel or biodiesel. Lifecycle greenhouse gas emission assessments by Argonne National Labs indicate that the climate advantages of renewable diesel over diesel or biodiesel vary widely, depending on the source of the fuel. Nonetheless, on a "well-to-wheels" basis (taking into account every stage of the fuel's production, distribution, and combustion in a vehicle), GHG emissions from renewable diesel are between 36% and 81% lower.

However, from an air quality standpoint, renewable diesel offers modest emission reductions compared to biodiesel, and only limited benefits compared to Zero- and Near-Zero engines. The most recent data from California's South Coast Air Quality Management District and Air Resources Board indicate a wide range of potential reductions in criteria pollutants depending on the age of the vehicle.[18]

For pre-2009 trucks and buses, on average, renewable diesel can reduce emissions of nitrogen oxides by 12% and particulates by 30%. However, for newer diesel vehicles equipped with diesel particulate filters (2010-2014), the comparative benefits are less clear—NOx emissions ranged from a 13% decrease to a 24% increase; PM emissions ranged from no discernible change to a significant increase.[19]

Renewable diesel has been available predominantly in California, and because it is more expensive to produce, it is considerably higher priced than conventional diesel or biodiesel.[20,21] It sells at a hefty premium—$1.50 per gallon in NYC during the initial pilot, meaning that if all the heavy-duty trucks in the NYC fleets converted to use of this fuel, the city would pay a hefty $26 million premium in fuel costs each year.[22] The fuel must also be delivered to refueling stations by truck, rail or barge as it cannot travel in the country's oil pipelines.

In part because of the elevated price and the need to transport it to customers (via truck, rail and/or barge), Renewable Diesel has been used mainly in California. Several public and private fleets have made commitments to Renewable Diesel, especially in California's Bay Area. Statewide in 2016, approximately 250 million gallons of Renewable Diesel were consumed. San Francisco, Oakland and San Jose have all made major procurement commitments, and ferry and train operators are exploring the option as well.[23]

In northern California, Alameda and San Joaquin counties are using renewable diesel. (Source: Government Fleet)

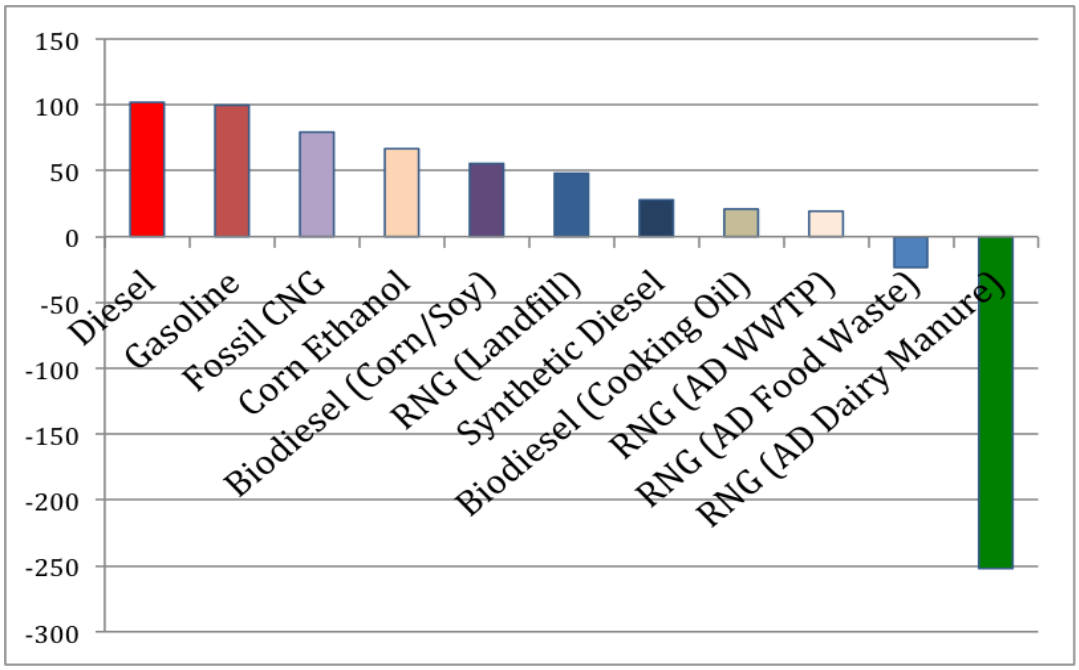
Renewable Natural Gas (RNG). The fourth non-fossil fuel, near-zero technology option, while only briefly mentioned in the New York City *Clean Fleet* plan from 2015, offers the greatest advantages from both the greenhouse gas reduction and clean air perspectives as well as other important benefits. This gaseous fuel, called "biomethane" or Renewable Natural Gas "RNG," is an already commercial option made by capturing and refining the methane-rich biogases emitted by decompos-ing organic wastes—food wastes, animal manure, wastewater, etc.

Biomethane, as mentioned in this report's introduction, is chemically similar to conventional natural gas, but it has all the characteristics required for a fully sustainable fuel. It is made from a renewable resource (organic wastes), so it involves no fracking or other forms of drilling. When burned in a near-zero engine vehicle it emits the same low NOx and PM emissions (90% below the EPA standards) as conventional natural gas.

On a lifecycle basis, RNG offers the lowest greenhouse gas emissions of any commercially available fuel, according to the California Air Resources Board, a leader in evaluating vehicle fuels. It reduces lifecycle greenhouse gas emissions by 70% to 300% as compared to conventional diesel or gasoline. How can this be?

Since biomethane is made by capturing waste-derived biogases that would otherwise escape into the atmosphere, it is often a totally net-carbon-neutral fuel. However, when it is made using separated food waste or animal manure as the primary source of the biogases, the fuel is actually *net-carbon-negative*. That is because, on a lifecycle basis, the amount of GHGs (methane) trapped to make the fuel far exceed the amount emitted (in the form of carbon dioxide) when it is burned in vehicles.

Figure 3. ***Lifecycle Carbon Intensity; Diesel & Non-Petroleum Vehicle Fuels (Measured in grams of CO2 equivalent per Mega Joule)***



Detailed lifecycle analyses by the California Air Resources Board highlight the fact that organic waste-derived biomethane is the lowest carbon commercially available transportation fuel option that exists. In fact, when made from food waste or animal manure, the fuel is "net-carbon-negative".

One of L.A. Metro's 295 "Near Zero" emission buses that run on renewable natural gas (RNG). (Source: LA Metro)

Further, producing RNG helps solve a major waste disposal problem: it turns organic wastes (about a third of the municipal waste stream) from "garbage" to a valuable resource. As such, the organic-waste-to-fuel strategy can help NYC and other cities meet their zero-waste goals.

Anaerobic Digester "Eggs" at NYC DEP's Newtown Creek Wastewater Plant in Greenpoint, Brooklyn. The facility is processing separated food scraps along with wastewater to produce biogas that will soon be refined to meet National Grid's gas quality specifications. (Source: NYC DEP)

Today, more than 50 plants in the US produce RNG for use in vehicles. Because the fuel itself is chemically similar to conventional natural gas (four hydrogen atoms and one carbon atom, or CH4), RNG is completely compatible with existing technology and infrastructure: commercial engines that burn CNG, as well as an extensive network of natural gas distribution and refueling stations that now deliver conventional natural gas. As a result, a change in purchasing contracts would enable all existing natural gas vehicles in the city, including the 42 operated by DSNY, the almost 200 in the City's light- and heavy-duty fleets, as well as the 800 CNG MTA buses, to buy this ultra-low-carbon fuel instead of CNG. Moreover, the two major providers of natural gas vehicle fuel to NYC fleets today—Clean Energy Fuels and Love's-Trillium—have both committed to providing this fuel to NYC fleets at the same cost as CNG.

Fuel buyers might wonder, since RNG and CNG travel through the same pipelines and their molecules are similar, how they can be certain that they are actually getting RNG instead of CNG. To prevent fraud and ensure the authenticity of RNG, third-party verifiers work directly with the fuel producers, the EPA, and CARB in California to track the fuel from the point of production to distribution and all the way to vehicle end users. There is a robust system in place to ensure the amount of RNG fuel sold to fleets—near or far—matches the volume of fuel produced at the facility from which it came.

While no vehicle fleets in NYC currently use RNG, it is being used in more than 20,000 trucks and buses across the US. The entire Santa Monica, California bus fleet is converting to biomethane fuel and near-zero engines. In Los Angeles, LA Metro recently purchased almost 300 new transit buses using the near-zero engine/biomethane fuel combination, and has an option to convert its entire 2,200-bus fleet. (LA Metro also purchased 95 electric buses to test them.)

Hundreds of UPS trucks around the country are fueled with RNG, as are the trucks of many private waste companies, including Republic Services and Waste Management, the nation's largest private hauler, with 6,000 natural gas trucks. In Sacramento, California, the private refuse company Atlas Disposal has been producing this fuel from local organic waste for use in its fleet plus municipal and county fleet vehicles for five years—a closed-loop system. The City of Surrey in British Columbia has a closed-loop system as well. And a number of large cities, including Portland, Oregon, and Toronto, Ontario, have projects in development.[22]

Figure 4. ***Analysis of Non-Diesel Fuel Options for NYC's Medium- and Heavy-Duty Trucks Compared to a New (2010-2014) Conventional Diesel (Fuel + Engine) Baseline***

Fuel Source	Lifecycle GHG Emissions	Tailpipe Emissions, NOX	Tailpipe Emissions, PM	Vehicle Cost	Fuel/Energy Cost (per gallon equivalent)	Maintenance Cost (per mile)	Availability
Battery Electric[1]	-60%	-100%	-100%	+$280k	-$.40-.70	-$0.25	Demonstration
CNG + NZ[2,3]	-29%	-90%	-98%	+$50k	-$.25-.60	0	Commercial
Renewable Diesel[4,5]	-30-80%	-13% to +29%	0%	$0	+$1.50	0	Regionally Available
RNG + NZ[6,7]	-70-300%	-90%	-98%	+$50k	-$.25-.60	0	Commercial

[1] Battery electric GHG emissions based on emissions from NYC grid electricity compared to emissions from diesel, per "Inventory of NYC Greenhouse Gas Emissions in 2015." Vehicle cost figure based on 2017 CARB data for 324 kwh depot charge bus

[2] CNG + NZ reduction in GHGs taken from GREET WTW calculator; *including 9% GHG reduction from closed crankshaft on NZ engine.*

[3] Tailpipe emissions for CNG+NZ taken from CARB certification certificates for Cummins Diesel and Cummins NZ NG engines, based on Supplemental Emissions testing reading

[4] Renewable diesel GHG reduction is average based on 6 energy crops and tallow using Argonne GREET WTW calculator, linked at https://greet.es.anl.gov/results

[5] Renewable diesel PM and NOX reductions based on California EPA "Staff Report: Multimedia Evaluation of Renewable Diesel," May 2015, https://www.arb.ca.gov/fuels/diesel/altdiesel/20150521RD_StaffReport.pdf

[6] GHG reductions from RNG + NZ based on various RNG sources in "LCFS Pathway Certified Carbon Intensities" tables, https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm, except dairy manure, taken from "CARB Staff Summary Method 2B Application: Prospective Pathway, Dairy Biogas to CNG," January 2016. https://www.arb.ca.gov/fuels/lcfs/2a2b/apps/calbio-sum-122115.pdf *Does not include 9% GHG reduction supposedly coming from NZ engine.*

[7] Tailpipe emissions for RNG + NZ engines assumed to be same for CNG + NZ

Zero or Near-Zero Emission Vehicles: A Clean Air Strategy for All New Yorkers

The Four Non-Petroleum-Diesel Strategies

Renewable diesel, while it does not rely on petroleum-diesel fuel, still does rely on the use of diesel engines – which appear increasingly as an outdated engine technology. They have not been certified as a zero- or near-zero-emission strategy and are 50% to 80% noisier on the streets than natural gas engines, and 100% noisier than electric. Most important, this strat-egy results in only modest reductions or even increases in NOx and PM. Moreover, a recent report by the University of California Riverside's Center for Environmental Research & Technology indicated that medium- and heavy-duty diesel engines often fail to meet their EPA certification standards, especially in urban applications. CARB and UC Riverside inde-pendently concluded that "in-use NOx emissions from heavy-duty diesel trucks were 1.7 to 9 times higher" than the NOx certification standard during low-speed city driving conditions.[25]

The other three of the four non-diesel strategies—Electric, Compressed Natural Gas (CNG), and Biomethane (RNG)— would require a complete transition away from the diesel engines and liquid fueling infrastructure that the City has relied on for decades. Yet, from a health perspective, these three deserve to be the highest priority choices.

Top Priority—Safeguarding the Health of New Yorkers: In New York City, according to the April 2017 Community Air Survey, "the largest share of adverse health outcomes from traffic came from trucks and buses traveling the city's streets, ac-counting for more than half of PM2.5-related health outcomes from on-road traffic." Moreover, as indicated in the report's introduction, the health effects associated with petroleum-diesel emissions disproportionately impact the highest-poverty and minority neighborhoods—1.5 times higher levels of PM2.5 and 8.3 times higher rates of asthma emergency room visits compared to affluent neighborhoods (see Figures on p. 15). As a critical environmental justice issue, fleet conversions to clean fuels should prioritize these neighborhoods. And once the City takes the lead in transitioning its own fleet vehi-cles, city leaders should also address the significant portion of diesel emissions generated by the thousands of old privately owned medium- and heavy-duty diesel trucks – a further burden on these neighborhoods.

Figure 4a. ***Annual Health Impacts of Traffic-Related PM 2.5 Exposure in New York City***

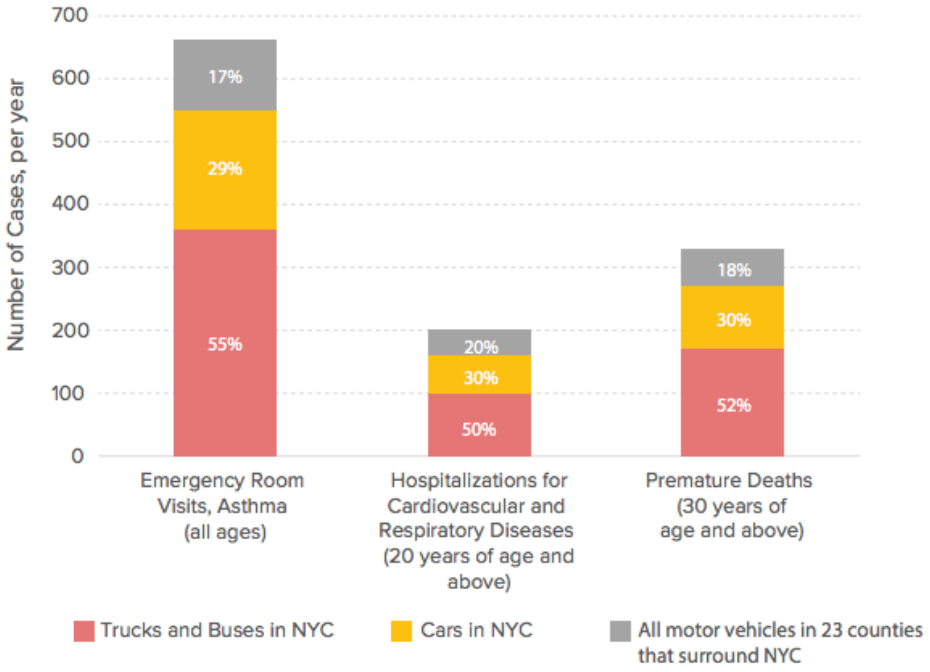


Figure 4b. ***PM 2.5 Exposure in Relation to Poverty; NY Metropolitan Area***

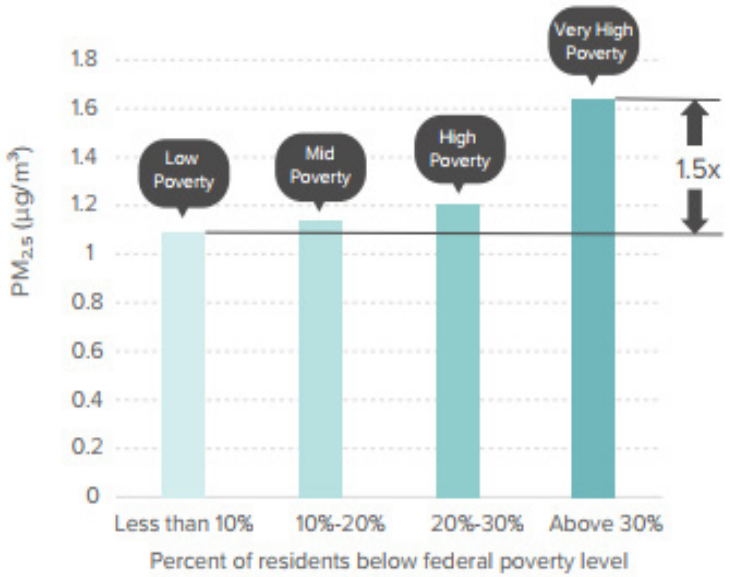
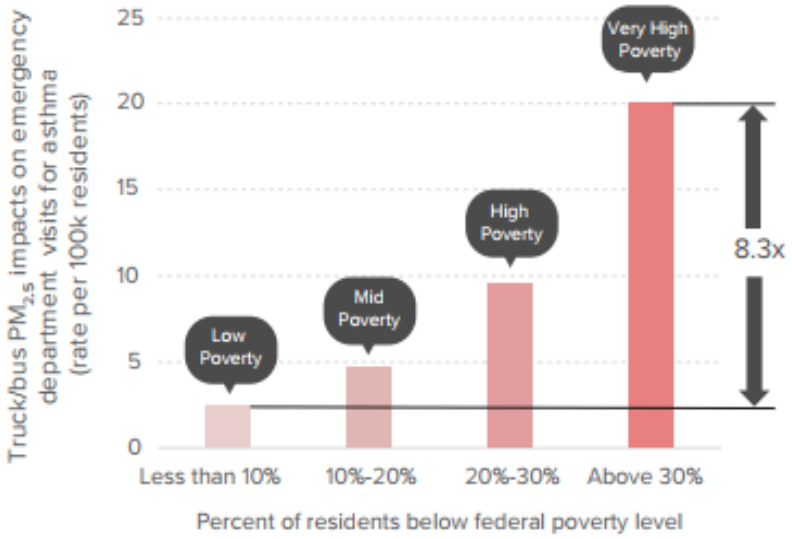


Figure 4c. ***The Relationship Between Heavy-Duty Vehicle Pollution, Poverty and Emergency Room Asthma Visits in NYC***



Source (3 Figures): New York City Community Air Survey, 2008-2015

Top Priority for Diesel Displacement: NYC's Medium- and Heavy-Duty Fleets

There are approximately 10,000 diesel vehicles in the City's fleets, but it is the roughly 6,300 heavy-duty vehicles that demand the most attention. As illustrated in the tables below, the Department of Sanitation, with the highest number of heavy-duty vehicles, also has the highest diesel consumption (in the form of a biodiesel blend) and accounts for the highest levels of health-threatening emissions—including of PM and NOx—despite the Agency's widespread use of advanced emissions control systems. This clearly demonstrates a correlation between the emissions reductions that the City seeks to achieve in its 80 x 35 goal and the primary role played by the heaviest duty vehicles within agency fleets. Without changes in these vehicles specifically, reaching the 80 x 35 target will be difficult to achieve.

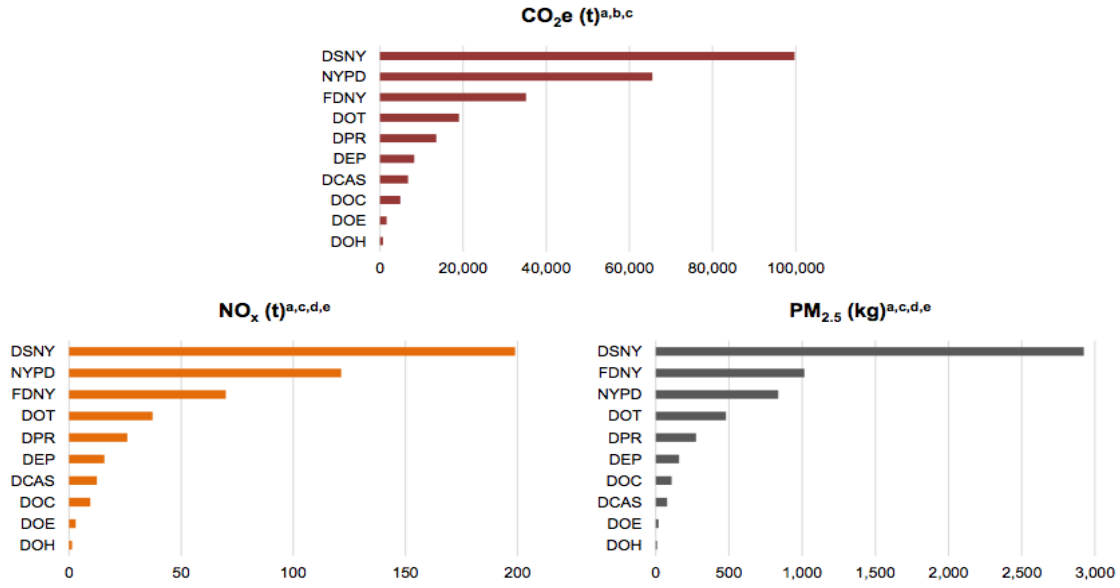
NYC Department of Sanitation Heavy-Duty Trucks at a Depot in Astoria, Queens. (Source: DSNY)

Table 3. ***Heavy-Duty Vehicles, Diesel Consumption and Emissions by NYC Agencies, 2017****

CITY AGENCY	FY 17 Actual count of heavy duty vehicles	FY 17 Total diesel consumption, gallons	Total estimated CO2e emissions, metric tons	As % of total emissions for heavy-duty fleets	As % of required emission reduction (198,000 metric tons)
Dept. of Sanitation (DSNY)	3,808	10,198,985	103,381	63.05%	52.21%
Fire Dept. of NY (FDNY)	221	2,736,267	27,736	16.91%	14.01%
Dept. of Transportation (DOT)	864	1,173,303	11,893	7.25%	6.01%
Dept. of Parks & Rec. (DPR)	354	657,500	6,665	4.06%	3.37%
NY Police Dept. (NYPD)	440	508,524	5,155	3.14%	2.60%
Dept. of Env. Protection (DEP)	439	395,086	4,005	2.44%	2.02%
Dept. of Corrections (DOC)	194	324,386	3,288	2.01%	1.66%
Dept. of Education (DOE)	24	183,003	1,855	1.13%	0.94%
TOTAL	***6,344***	***16,177,054***	***163,977***	***100.00%***	**82.82%**

**Heavy-duty vehicle numbers and agency diesel consumption; from the Mayor's Management Report, September 2017; Emissions values based on 22.3 lbs. CO2e per gallon diesel, per U.S. EIA. The Mayor's Management Report seems to refer to all "biodiesel,"as City agencies have a 5% minimum requirement.*

Figure 5. ***Vehicle Air Emissions (CO2e, NOx, PM) by City Agency in FY 2015***[27]



[a] Fuel consumption data (gasoline and diesel by agency) from DCAS
[b] Global warming potential from Appendix J of 2013 New York City GHG Inventory (City of New York, 2014)
[c] DOE figures do not include school buses operated under contract
[d] Uses average fuel economy (21.4 mpg gasoline, 6.3 mpg diesel) from FHWA's 2011 Highway Statistics, Table VM-1 (2013)
[e] Uses average in-use emission rates of NO_x and $PM_{2.5}$ for gasoline from EPA (2008a) and for diesel from EPA (2008b)

Source: NYC Clean Fleet 2015 report

Choosing the Best Path Forward for New York City

Table 4 below shows examples of the greenhouse gas reductions achieved by converting 1,000, 3,800 or 5,667 trucks from diesel to RNG (assuming a modest average per-vehicle GHG reduction of 80% compared to diesel and biodiesel blends, which would exceed 100% for food waste-derived renewable natural gas).

Table 4. ***GHG Reduction in Heavy Duty Trucks: 3 Scenarios Replacing Diesel with Biomethane Showing GHG Reductions in the trucks alone and how they would affect reaching NYC's 80 x 35 goal (combined with "whole fleet" strategies)***

	Number of Trucks	Diesel Displacement (gallons/year)	GHG Reduction (MT CO2e)	% Reduction (RNG only)	% Reduction (RNG + Whole Fleet Strategies)
Scenario 1	1,000	3,000,000	24,327.27	12.29%	45%
Scenario 2	3,800	11,400,000	92,443.64	46.69%	80%
Scenario 3	5,667	17,001,000	137,862.65	69.63%	103%

**For the purposes of this example, all scenarios assume 10 gallons of diesel fuel consumed per vehicle per day; 22.3 pounds of GHG emissions per gallon of diesel, per the City's 2015 Greenhouse Gas Inventory; 2,200 lbs. to the metric ton; an 80% reduction of emissions relative to diesel from using biomethane; and vehicles on the road 300 days per year.*

With all the environmental and public health benefits of replacing diesel trucks with those powered by CNG or RNG, a critical question becomes: is such a shift economically feasible? The City has indicated that it plans to commit up to $6 billion for fleet sustainability measures over 20 years (by 2035).[28] And the good news is that the additional costs of buying trucks with near-zero engines (about $50,000 more per vehicle) and of prop-erly ventilating indoor depots (approximately $500,000 per maintenance depot, although the specific characteris-tics of each site may make these costs differ widely) represent just a fraction of this amount.

For example, replacing 3,800 heavy-duty diesel vehicles with models running on RNG (Scenario 2, above) would meet the City's 80 x 35 goal, at an incremental cost of roughly $190 million spread out over 10-12 years, depending on each agency's vehicle replacement cycle. (This does not include fuel and maintenance cost savings associated with a transition from diesel to waste-derived biomethane.) In the case of the DSNY fleet, complete replacement could take place over seven years, the accepted standard for vehicle replacement in that fleet since the 1980s. In addition to distributing the costs over time, a multi-year transition would be appropriate to allow maintenance teams to become acquainted with new systems and vendors to align their operations with new city requirements.

Furthermore, over the long-term the City is well-positioned to have *its own waste-streams used to produce renewable natural gas*, which has additional economic benefits. In addition to the biomethane currently produced at Fresh Kills landfill, NYC has ample supplies to produce this ultra-low-carbon fuel. The 1.2 million tons of food waste generated by the City's residents and businesses, if processed in anaerobic digesters (including at Newtown Creek and a handful of private facilities under development in the region), could produce enough RNG to displace ALL of the 17.6 million gallons of diesel fuel consumed by the City's heavy-duty vehicles.[29] And that doesn't include the 13 other wastewater treatment plants the City owns and operates whose biogases could be used to produce RNG as well.[30]

Developing and using our local biomethane resource could save the City millions of dollars on fleet fuel, help address its own goal of zero waste to landfills by 2030, and provide revenue from sales of both renewable natural gas and the valuable soil amendments composed of organic waste "digestate" left after the digestion process.

The City deserves credit for the progress made toward its *Clean Fleet* (80x35) and *OneNYC* clean air goals. Shifts of light-duty vehicles to electric models and integration of biodiesel blends fleet-wide have reduced emissions moderately. But reaching and exceeding these goals will require a major shift away from diesel fuel not yet embraced in the 2015 *Clean Fleet* plan. Fortunately, as described above, there are proven technologies that can get us there, and clear indicators of how to prioritize their application. Getting there, however, will require swift action.

While fleets have had the complete freedom to select the trucks they want, their choices have not been rigorously considered in light of public health and greenhouse gas reduction goals that are urgent public priorities. It makes sense to align the two. The City Council is now in a position to take action to align fleet purchasing with the City's climate and clean air goals, by calling for the phase-out of the purchase of diesel vehicles in favor of zero- and near-zero emission technologies that are available now. And the Mayor, with his important commitment to ending New York City's reliance on fossil fuels and to making New York City a global example, has every reason to make his voice a leadership voice for change.

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Comments on "Ending the Diesel Era"

"Energy Vision is doing great work. Getting rid of diesel is the right thing to do. It will improve the quality of life. It will be highly cost-effective. And it can solidify New York City's position as an environmental leader among American cities."

Dr. Philip J. Landrigan, Dean for Global Health, Professor of Preventive Medicine and Pediatrics, Arnhold Institute for Global Health, Icahn School of Medicine at Mount Sinai

"Our children are our future, and in one of this country's greatest cities, we must set an example giving them a healthy environment to grow up in. Energy Vision has long been a leader in finding solutions, and this new report on ending the diesel era has done it again."

Blythe Danner, Actor and Environmental Advocate

"For too long diesel fumes from NYC's buses and trucks have been poisoning our children and families. Energy Vision's report shows that we no longer need to rely on diesel engine technology and fuel. Better choices are available. It's time for the City Council and Mayor to provide leadership in moving our fleets to the fuels of the future."

Cecil D. Corbin-Mark, Deputy Director & Director of Policy Initiatives, WE ACT for Environmental Justice

"Congratulations to Energy Vision for this valuable report. Using its highly respected technology expertise, Energy Vision clarifies the ways in which New York City's fleets can most effectively tackle their climate change and air pollution challenges; it also promises to be a superb resource for other cities struggling with these same issues."

Robert B. Catell, Chairman Advanced Energy Center (AERTC) at Stony Brook University

"The disproportionate health impacts from diesel trucks is one of the most important environmental justice issue in New York City. While all neighborhoods will benefit from a transition to lower emission vehicles, neighborhoods with the highest air pollution-related health impacts deserve to be prioritized as fleet conversion occurs."

Kevin R. Cromar, Ph.D., Director of the Air Quality Program and Clinical Associate Professor
NYU Marron Institute of Urban Management

"DSNY takes pride—and rightly so—in efficiently operating the largest refuse fleet in the US. So why is it dragging its feet in replacing its outmoded diesel trucks with the more sophisticated technology available today? The new 'Near Zero' natural gas engines are here. A cleaner natural gas fuel (made from waste) is here, and existing refueling stations now providing conventional natural gas can deliver this new fuel reliably. And these trucks are affordable. All DSNY has to do is do it. The health and environmental benefits cry out for responsible action."

Norman Steisel, CEO of EnEssCo Strategies, Former DSNY Commissioner and First Deputy Mayor
Board of Directors of Energy Vision

"Energy Vision's new report is just the kind of resource that New York policymakers need as they seek to address New York's significant air pollution and climate change issues."

Marcia Bystryn, President, New York League of Conservation Voters

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