New York City
Commercial Refuse Truck
Age-out Analysis

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Executive Summary

This report summarizes an analysis of the costs and air quality benefits of setting "age-out" provisions for the commercial carting fleet in New York City. The analysis focuses on "License" trucks used for hauling commercial putrescible waste & recyclables, and "CL-2 registration" trucks used to haul construction and demolition debris. Trucks in both of these fleets are operated by a number of private carting companies which are regulated by the New York City Business Integrity Commission (NYCBIC).

The License fleet currently contains 4,281 active trucks and the CL-2 fleet contains 4,065 active trucks; the total size of both fleets has remained stable over the past five years. Both fleets include trucks ranging in size from Class 5/6 (16,000 – 26,000 lbs gross vehicle weight) to Class 8B (>60,000 lbs gross vehicle weight). Many trucks in the License fleet are equipped with rear-load "packer" bodies for collecting and compressing individual bags and bins of refuse; other types of trucks found in this fleet include grease tankers, and box trucks used to collect shredded paper. Trucks in the CL2 fleet include dump trucks, as well as trucks with rear-load packer bodies, and trucks equipped with roll-off hoists for loading and carrying metal dumpsters.

The average age of current CL2 trucks is greater than 14 years old, and the average age of current License trucks is almost 16 years old. About one quarter of all trucks are 20 years old or older; the oldest trucks in each fleet are more than 30 years old. Currently the License and CL2 fleets together are estimated to produce 2,188 tons of NOx and 125 tons of PM annually.

NYCBIC also regulates "CL1" trucks - these are generally light-duty pick-up trucks used by landscapers. This analysis does not include these CL1 trucks for two reasons: 1) these light-duty trucks are much smaller than License and CL2 trucks and therefore use significantly less fuel and produce much fewer emissions per mile and per year, and 2) many of these trucks use gasoline engines rather than diesel engines.

This analysis evaluated the potential air quality benefits of requiring commercial carting companies in New York City to retire their older trucks and replace them with new or used trucks built in 2007 and later, which meet more stringent EPA emission standards. Five different policy cases were analyzed, in relation to a "business as usual" baseline. The baseline assumes that the current fleet will continue to turn-over to new trucks at a relatively slow pace consistent with recent experience - such that the average age of the fleets will be maintained at approximately 14 -15 years old through 2030.

The five policy cases evaluate the effects, compared to the baseline, of requiring faster turn-over to new trucks over a range of time frames. Policy Case 1 evaluates the effect of requiring all pre-1994 trucks to be retired by January 1, 2016, and replaced with trucks of model year 2007 and newer. Policy cases 2, 3, and 4 evaluate the effect of requiring all pre-2007 trucks to be retired, and replaced with new or used trucks no more than a few years old, as of January 1, 2020, January 1, 2025, and January 1, 2030, respectively. Policy case 3A combines aspects of Policy Case 1 and Policy Case 3 – under this scenario all pre-1994 trucks would be retired by January 1, 2016 and all pre-2007 trucks would be retired by January 1, 2025.

For the baseline and each policy case total annual fleet emissions of NOx and PM were calculated for each year between 2013 and 2030, using EPA emission factors. For each case the total cost of purchasing new trucks each year was also estimated based on data from TruckBlueBook.com.

See Table 1 for a summary of the projected benefits (PM and NOx reductions) and costs of each policy case compared to the baseline scenario. As shown, over the next 17 years PM emissions under the business as usual baseline are expected to total 1,368 tons, and NOx emissions are expected to total 23,198 tons. During that time period, the carting companies are also expected to spend $571 million to purchase new trucks (NPV fleet turnover costs). This figure is the net present value of expected expenditures, in 2013 dollars.

Table 1 Summary of Results – Costs and Benefits License and CL2 Fleets

2013 - 2030		BASELINE	POLICY CASES				
			1 Retire all pre-1994 Trucks by Jan 2016	2 Retire Pre-2007 Trucks by 2020	3 Retire Pre-2007 Trucks by 2025	3A Retire pre-1994 by 2016 & retire pre-2007 by 2025	4 Retire Pre-2007 Trucks by 2030
PM Emissions (tons)		1,368	974	572	837	754	1,103
NOx Emissions (tons)		23,198	17,280	11,144	15,073	14,285	19,067
NPV Fleet Turnover Cost ($ mill)		$571.4	$622	$1,056	$867	$788	$673
INCREMENTAL TO BASELINE	PM Reduction (ton)		393	796	531	613	265
	NOx Reduction (ton)		5,918	12,054	8,125	8,914	4,132
	NPV Costs ($ mill)		($51)	($484)	($296)	($216)	($101)
NPV Potential Maintenance Cost Savings ($ mill)			$0.12	$15.50	$8.40	$4.64	$1.36

Under Policy Case 1 (retire all pre-1994 trucks by January 2016) PM emissions from the fleet over the next 17 years are projected to total 974 tons – for a reduction of 393 tons compared to the baseline. This policy case will also result in a 5,918 ton reduction in NOx emissions over that time period. The total cost of purchasing new trucks under Policy Case 1 is estimated to be $622 million, which is $51 million more than the projected cost of new truck purchases under the baseline scenario (NPV Costs).

The projected PM reductions for the other policy cases range from 265 tons (Policy Case 4) to 796 tons (Policy Case 2), while the projected NOx reductions range from 4,132 tons to 12,054 tons.

The largest reductions come from Policy Case 2, but this scenario also has the highest costs.

Other than Policy Case 1, the scenario with the highest ratio of emission reductions to cost is Policy Case 3A. Under this scenario - which requires all pre-1994 trucks to be retired by 2016 and all pre-2007 trucks to be retired by 2025 – the projected PM reductions total 613 tons, the projected NOx reductions total 8,914 tons, and the projected costs total $216 million.

Also shown in Table 1 are the estimated maintenance cost savings associated with each Policy Case, which result from having a greater number of new trucks, and fewer very old trucks, in the fleet. As shown, over the seventeen year period covered by the analysis these estimated maintenance cost savings range from $120,000 to $15.5 million for the different Policy Cases. The estimated maintenance costs saving that result from each Policy Case are generally less than 3% of the incremental costs of purchasing new trucks, and if included as a benefit have only a marginal effect on the net cost for each Policy Case.

The average annual PM emission reductions that would result from Policy Case 1 would be equivalent to removing 168,846 cars from the roads of New York City every year between 2014 and 2030. The NOx emission reductions that would result from Policy Case 1 would be equivalent to removing an average of 70,596 old cars or 423,576 new cars from the roads.

Alternatively, the PM emission reductions from Policy Case 1 would be equivalent to removing 158,490 new or 12,192 old medium-duty commercial trucks from New York City streets, while the NOx reductions from Policy Case 1 would be equivalent to removing 16,119 new or 6,328 old medium-duty commercial trucks.

Vehicle equivalent values for the other policy options are higher than for policy option 1, in proportion to estimated emission reductions from these policy options; for example, the PM reductions from Policy Case 2 would be equivalent to removing more than 341,000 cars, or 320,000 new medium-duty commercial trucks from the city's streets every year.

As discussed in section 2, the assumptions used in this analysis are generally conservative, and may in fact understate air quality benefits and over-state compliance costs for each policy case. In addition, this analysis assumes that the air quality goals of each policy case will be met solely by retirement of older trucks, and replacement with new or post-2007 model year used trucks; because these newer trucks are equipped with engines that meet the most stringent EPA standards their emissions of PM and NOx will be more than 85% lower than emissions from older trucks equipped with older engines that do not meet stringent EPA standards.

Equivalent reductions in NOx and PM emissions could be achieved by repowering older trucks with new engines that meet current EPA standards - rather than replacing the entire truck - perhaps at lower total cost. In addition, in some cases equivalent reductions in PM emissions could be achieved by retrofitting existing older trucks with diesel particulate filters (DPF), at lower cost than replacing the truck with a new or used truck[1]. There are numerous DPFs commercially available that have been verified by EPA and/or the California Air Resources Board to reduce PM emissions from older diesel engines by 85% or more.

[1] DPFs do not reduce NOx emissions from older engines.

1 Background – Diesel Emissions and Health

The commercial refuse trucks in the License and CL2 fleets use heavy-duty diesel engines. Diesel exhaust includes substances that have been proven to be detrimental to both human health and the environment, including nitrogen oxides (NOx) and particulate matter (PM).

NOx is a direct respiratory irritant and also combines in the atmosphere with un-burned hydrocarbons, in the presence of sunlight, to form ground-level ozone or "smog".

PM particles formed by combustion of fossil fuels, including diesel fuel, are a complex mixture of elemental, or "black", carbon, unburned or partially combusted fuel, sulfate from fuel sulfur, and lubricant products. Diesel PM includes more than 40 substances considered by the United States Environmental Protection Agency (EPA) to be air toxins. Most particles emitted by diesel engines are small enough to be inhaled and lodged deep into the lungs[2]; they also can enter the bloodstream. Based on numerous air-quality studies EPA has determined that exposure to high levels of diesel PM causes cardiovascular harm and pre-mature death, is likely to cause respiratory harm, and may cause cancer[3].

Diesel PM also contributes to global warming. Approximately 80% of the mass of particulate pollution emitted by diesel engines is black carbon –also known as soot. Black carbon in the air warms the atmosphere directly by absorbing sunlight and radiating heat. Black carbon deposited on ice and snow reduces their reflectivity and accelerates melting, which indirectly contributes to further warming.

In the short term (20 years) black carbon is estimated to be as much as 2,000 times more potent as a warming agent than an equivalent amount of the greenhouse gas carbon dioxide (CO_2). Black carbon is therefore a significant contributor to the global warming that is resulting in climate change. Some scientists estimate that over the last 150 years the climate warming resulting from black carbon in the atmosphere has been 25 -50 percent of the warming resulting from CO_2 emissions[4].

Prior to 1988 the engines used in heavy-duty trucks were not regulated by U.S. EPA. Since then EPA has implemented several rounds of increasingly stringent standards for new engines that have made newer trucks dramatically cleaner than older trucks. The

[2] Most PM particles emitted by diesel engines are smaller than 2.5 microns mean aerodynamic diameter ($PM_{2.5}$). These "ultrafine" particles are considered to be more damaging to human health than larger particles.

[3] U.S. Environmental Protection Agency, *Integrated Science Assessment for Particulate Matter*, December 2009, EPA 600/R-08/139F

[4] T.C. Bond, et al, *Bounding the Role of Black Carbon in the Climate System: A Scientific Assessment*, Journal of Geophysical Research-Atmospheres, 2012

most stringent PM standards were implemented beginning with the 2007 model year, and the most stringent NOx standards were implemented beginning with the 2010 model year. As such, new trucks purchased today produce about 95% less PM and NOx than trucks purchased 20 years ago.

The policy cases analyzed here are designed to speed turn-over of the existing commercial refuse hauling fleet in New York City to trucks produced after model year 2007, through retirement of the oldest vehicles and replacement with new or late-model used trucks. In order to achieve the desired air quality benefits (PM and NOx reductions) it is not necessary for all trucks entering the fleet each year to be brand-new. All trucks produced since model year 2007 are equipped with engines that meet the most stringent EPA standards for PM, so replacement of older trucks with model year 2007 and later used trucks will also produce dramatic reductions.

2 Study Methodology

This section briefly discusses the methodology, data sources, and assumptions used in this study.

2.1 Existing NYC Commercial Refuse Truck Fleet

NYCBIC maintains information about the active fleet of trucks used by licensed commercial carters in New York City. This information includes the truck's vehicle identification number (VIN), which can be used to determine truck make, model, and model year. See Figure 1 for the model year distribution of the License fleet over the last seven years, and Figure 2 for the model year distribution of the CL2 fleet.

As shown, only 10% – 14% of the trucks in each fleet are currently newer than 2007 and therefore meet the most stringent EPA emission standards. Over the past six years, an average of only 56 new trucks have entered the CL2 fleet each year and an average of only 47 new trucks have entered the License fleet each year. This equates to less than 1.5% turn-over per year for both fleets.

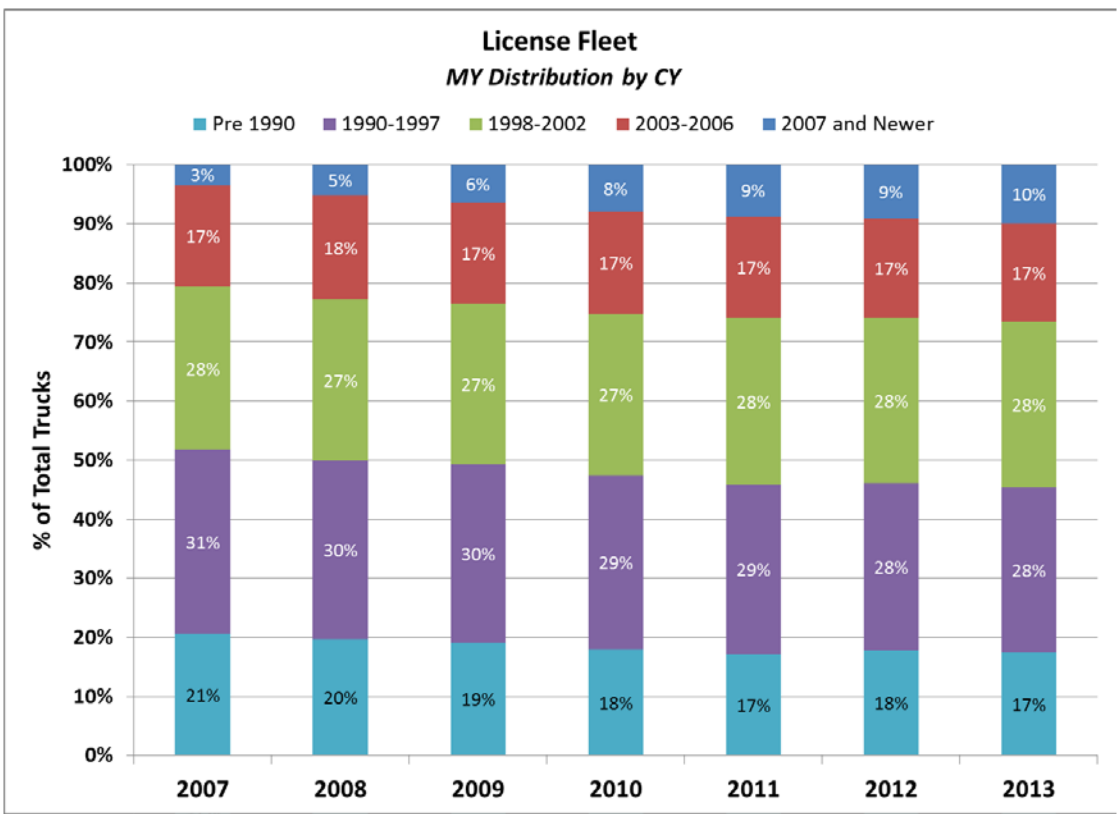

Figure 1 Model Year Distribution, License Fleet, 2007 - 2013

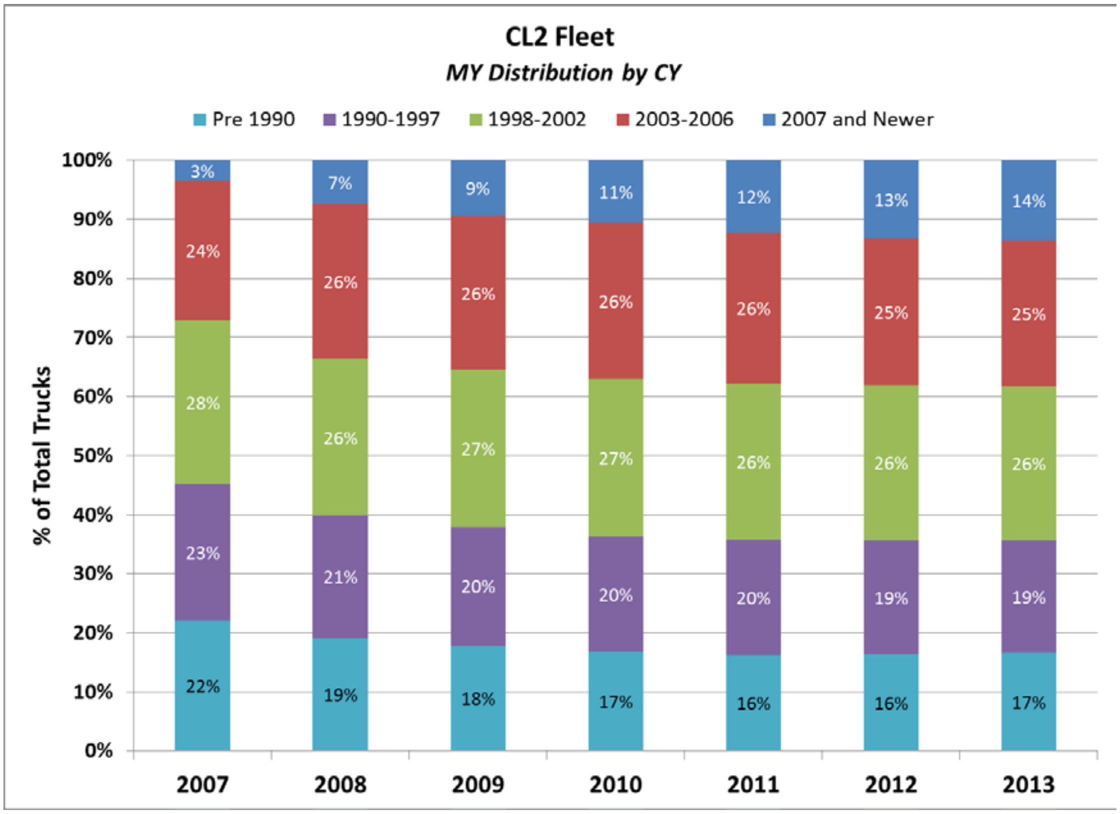

Figure 2 Model Year Distribution, CL2 Fleet, 2007 - 2013

This level of turn-over is not sufficient to maintain a stable average fleet age; since 2007 the average age of trucks in the CL2 fleet has increased from 10.4 to 14.2 years old, and the average age of trucks in the license fleet has increased from 11.0 to 15.6 years old.

It must be noted that this mirrors national trends. Historical data from the U.S. Census Bureau indicates that on average the in-use heavy-duty truck fleet turns over at an effective annual rate of 6 – 8% per year, based on annual miles traveled[5]. However, the recent recession of 2007 – 2009, and subsequent slow recovery, has dramatically reduced new truck sales compared to prior years. From 2004 to 2006 sales of new heavy-duty trucks (Class 6 – 8) in the U.S. averaged 490,000 per year, but sales fell to an

[5] Davis, Stacy, Oak Ridge National Laboratory, February 23, 2005; based on U.S. Bureau of the Census, *2002 Vehicle Inventory and Use Survey*, Micro data file, January 2005 (http://www1.eere.energy.gov/vehiclesandfuels/facts/2005/fcvt_fotw363.html)

average of 271,000 per year between 2007 and 2010[6]. Annual heavy truck sales were 305,000 in 2011 and 346,000 in 2012[7].

Table 2 Make and Model of MY2011-2013 Trucks in License and CL2 Fleets

LICENSE FLEET					
Code	**Make/Model**	**Count**	**%**	**CUM %**	**CLASS**
23	International 4300	26	16%	16%	6
42	Mack MR685S	19	12%	28%	8A
32	Kenworth T800	17	11%	39%	8A/8B
43	Mack MRU613	12	8%	47%	8A
38	Mack GU812	11	7%	53%	8A
39	Mack GU814	10	6%	60%	8A
24	International 4400	6	4%	64%	6
27	International 8600	5	3%	67%	7
37	Mack GU712	4	3%	69%	8A
47	Peterbuilt 320	4	3%	72%	8B
1	Autocar ACX64	3	2%	74%	8B
3	Autocar DK	3	2%	75%	8A
15	Freightliner CASCADIA	3	2%	77%	
29	Isuzu NPR	3	2%	79%	
45	Mack RD686SX	3	2%	81%	
48	Peterbuilt 337	3	2%	83%	
2	Autocar DC	2	1%	84%	
30	Kenworth T300	2	1%	86%	
49	Peterbuilt 348	2	1%	87%	
55	Toyota Tacoma	2	1%	88%	
6	Chevy Silverado	1	1%	89%	
7	Dodge Ram	1	1%	89%	
8	Ford F250	1	1%	90%	
9	Ford F350	1	1%	91%	
11	Ford F550	1	1%	91%	
12	Ford F650	1	1%	92%	
14	Ford Ranger	1	1%	92%	
16	Freightliner M2 106	1	1%	93%	
17	Freightliner M2 112	1	1%	94%	
19	Hino 258LP	1	1%	94%	
20	Hino 268	1	1%	95%	
21	Hino 338CT	1	1%	96%	
31	Kenworth T400	1	1%	96%	
36	Mack DM686SX	1	1%	97%	
40	Mack MC606P	1	1%	97%	
41	Mack MR685S	1	1%	98%	
44	Mack RD606S	1	1%	99%	
50	Peterbuilt 365	1	1%	99%	
56	Volvo VHD64	1	1%	100%	
	Total Trucks	**159**			

CL2 FLEET					
Code	**Make/Model**	**Count**	**%**	**CUM %**	**CLASS**
32	Kenworth T800	58	33%	33%	8A/8B
54	Peterbuilt 388	23	13%	46%	8A/8B
23	International 4300	13	7%	53%	6
4	Caterpillar CT660L	11	6%	59%	8A
11	Ford F550	8	4%	63%	5
17	Freightliner M2 112	6	3%	67%	7
37	Mack GU712	6	3%	70%	8A
38	Mack GU812	6	3%	74%	8A
33	Kenworth W900	5	3%	76%	8A
51	Peterbuilt 367	4	2%	79%	8B
25	International 660L	3	2%	80%	
59	Western Star 4900FA	3	2%	82%	
3	Autocar DK	2	1%	83%	
10	Ford F450	2	1%	84%	
26	International 7600	2	1%	85%	
29	Isuzu NPR	2	1%	87%	
30	Kenworth T300	2	1%	88%	
39	Mack GU814	2	1%	89%	
50	Peterbuilt 365	2	1%	90%	
53	Peterbuilt 386	2	1%	91%	
2	Autocar DC	1	1%	92%	
5	Chevy Kodiak	1	1%	92%	
12	Ford F650	1	1%	93%	
13	Ford F750	1	1%	93%	
16	Freightliner M2 106	1	1%	94%	
18	GMC Sierra	1	1%	94%	
22	International 1754	1	1%	95%	
28	International F5050	1	1%	96%	
34	Mack CHU612	1	1%	96%	
35	Mack CHU613	1	1%	97%	
45	Mack RD686SX	1	1%	97%	
46	Mack TD713	1	1%	98%	
52	Peterbuilt 382	1	1%	98%	
56	Volvo VHD64	1	1%	99%	
57	Volvo VHD64T	1	1%	99%	
58	Volvo VHD84	1	1%	100%	
	Total Trucks	**178**			

[6] In the U.S., trucks are characterized by class based on their gross vehicle weight rating (maximum weight of vehicle and pay load). Class 1 and 2 trucks (less than 10,000 pounds) are considered "light-duty" trucks, class 3 – 6 (10,000 – 26,000 pounds) are considered "medium-duty" trucks, and class 7 – 8 (greater than 26,000 pounds) are considered "heavy-duty" trucks.

[7] U.S. Department of Commerce, Bureau of Economic Analysis, *Motor Vehicle Unit Retail Sales, Table 5 -Heavy Trucks*, June 4, 2013

In order to determine which types of trucks are most prevalent in the CL2 and License fleets, the authors used VIN information to determine the make and model of all trucks purchased between 2011- 2013 and which are currently in these fleets as of June 2013. This data is summarized in Table 2.

As shown, both fleets include medium-duty trucks (Class 5 – 6) and heavy-duty trucks (Class 7 – 8A/8B). Based on this data about 30% of the License fleet is medium-duty, 50% are Class 7/8A, and 20% are the largest Class 8B trucks. The CL2 fleet has a higher percentage of the largest trucks; 20% are medium-duty, 20% are Class7/ 8A, and 60% are Class 8B.

There is also significant commonality of vehicle model between the two fleets. There are ten different truck models that make up over 70% of the new trucks purchased for both fleets in the last three years.

2.2 Refuse Truck Emission Factors

For this study the authors used NOx and PM emission factors from EPA's MOVES emissions model. For each calendar year this model can determine emission factors in terms of grams of emissions per mile driven (g/mi) for various types and model year of trucks operating over various types of roadways. The factors used for this analysis represent national average emissions from truck type = refuse truck, and roadway type = urban unrestricted[8]. For each calendar year in the analysis (2013 – 2030) emission factors were determined for trucks of model year 1990 through the model year equivalent to the calendar year; all trucks older than 1990 were assumed to have the same emissions as 1990 trucks.

See Figure 3 for an example of the PM emissions factors used for Calendar Year 2020, and Figure 4 for an example of the NOx emissions factors used for Calendar Year 2020. As shown, pre-1990 trucks are assumed to emit more than 1.5 g/mi PM and more than 30 g/mi of NOx. Model year 2007 and later trucks are assumed to emit only 0.028 g/mi PM because they were built to comply with the most stringent EPA new engine emission standards.

Model year 2010 and later trucks are assumed to emit only 1.3 – 2.1 g/mi NOx because they were built to comply with the most stringent EPA new engine emission standards. Emissions from these newer trucks are more than 95% lower than emissions from the oldest trucks.

[8] This is the designation used by EPA for local streets and arterial highways. Limited access highways are designated as "restricted".

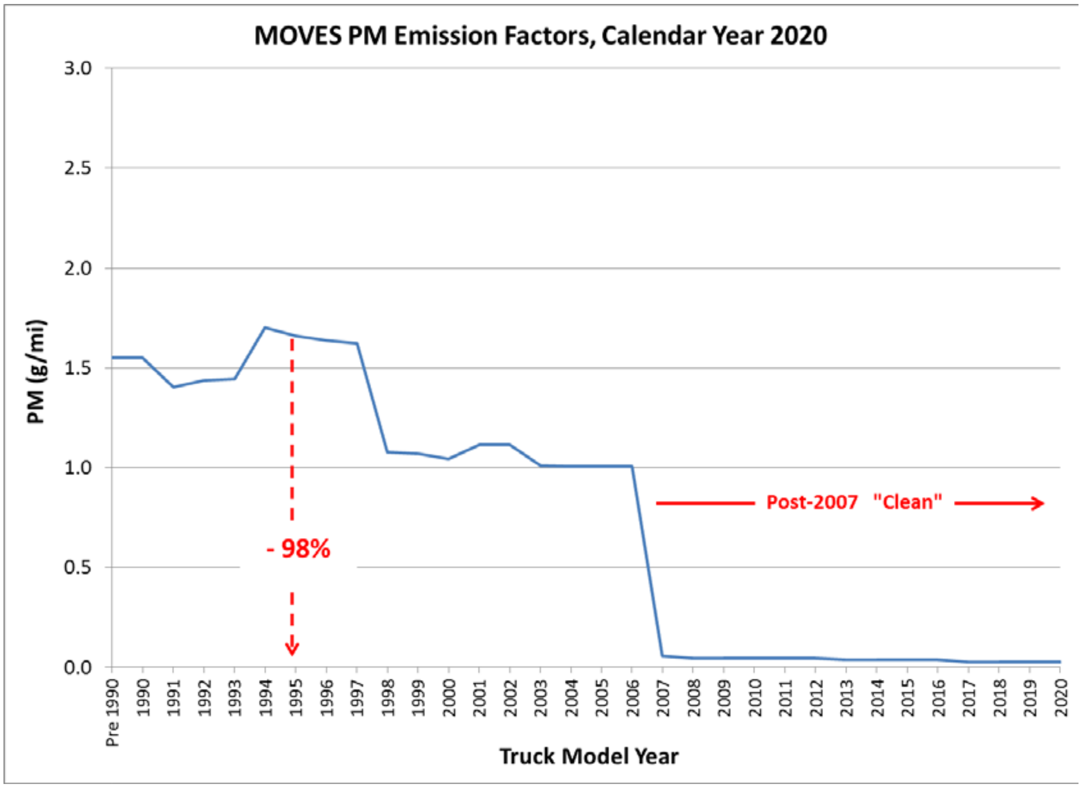

Figure 3 PM Emission Factors (g/mi) For Refuse Trucks of Various Age in CY 2020

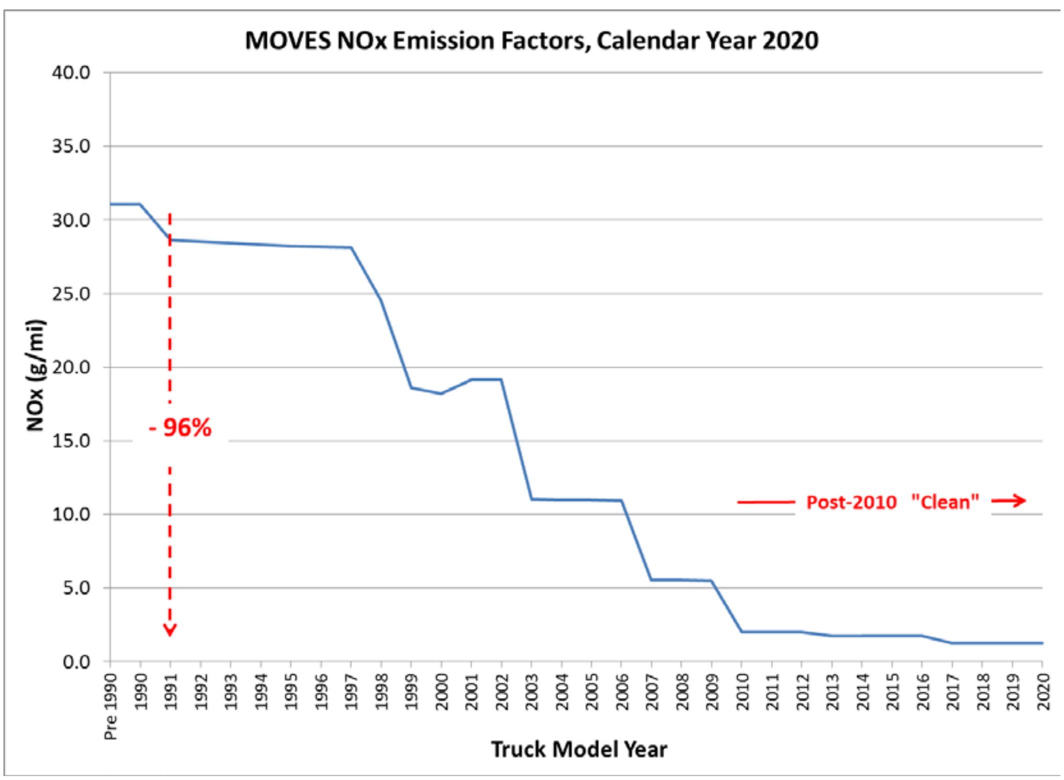

Figure 4 NOx Emission Factors (g/mi) For Refuse Trucks of Various Age in CY2020

2.4 Vehicle Replacement Costs

For this analysis the "costs" associated with each policy case are the estimated costs to purchase new or used trucks in order to replace older vehicles in the fleet to comply with age-out requirements.

Vehicle costs were estimated based on three "model" trucks that represent each of the three typical vehicle sizes in both the License and CL2 fleets: International 4300 (Class 6), Mack GU812 (Class 8A), and Kenworth T800 (Class 8B). As shown in Table 2 these specific truck models make up 34% of recent model year trucks in the License fleet and 43% of recent model year trucks in the CL2 fleet.

For these truck models the cost of buying new and used truck chassis and vocational bodies[9] was estimated based on data in TruckBlueBook.com, a service which tracks truck prices. For the License fleet all trucks were assumed to have rear-load packer bodies, while for the CL2 fleet trucks were assumed to have a mix of dump bodies, roll-off hoists, and rear load packer bodies.

See Table 3 for the estimated weighted average cost of new and used License trucks in 2013, and Table 4 for the estimated weighted average cost of new and used CL2 trucks in 2013. The assumed percentages of different truck sizes in each fleet are based on the data shown in Table 2.

As shown, in 2013 the average cost of a new (MY 2013) License truck chassis (including engine) is estimated to be $106,435 while the cost of a chassis and vocational body is estimated to be $143,285. In 2013 the average cost of a three-year old truck (MY2010) chassis for the License fleet is estimated to be $56,603, while the costs of a chassis and body is estimated to be $81,283.

In 2013 the average cost of a new (MY 2013) CL2 truck chassis is estimated to be $117,450 while the cost of a chassis and vocational body is estimated to be $145,826. In 2013 the average cost of a three-year old truck (MY2010) chassis for the CL2 fleet is estimated to be $67,725, while the costs of a chassis and body is estimated to be $86,640.

For years beyond 2013 the analysis assumes that 2013 new and used truck prices will increase at an average rate of 3% per year.

To calculate the net present value of costs (2013 dollars) for each policy case a discount rate of 6% was used.

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[9] Medium and heavy-duty trucks are typically composed of a "chassis" (i.e. cab and frame, with engine, transmission, and wheels) manufactured by one company, equipped with a "vocational body" (i.e. refuse packer, dump body, or box body) manufactured by a different manufacturer. Many different types of trucks can use the same chassis (make/model) even though they are equipped with very different bodies.

Both the baseline and all policy cases assume that when trucks are retired from the fleet both the chassis and vocational body is retired. The costs for all new and used trucks entering the fleet are therefore assumed to be the weighted average cost of a chassis and body, not just a chassis.

Table 3 Weighted Average Cost of New and Used License Trucks in 2013

Weight Class	% of Trucks [1]	Equipment	Make	Model	Description	% of Bodies [2]	Purchase Cost in CY2013 [3]						
							MY2013	MY2012	MY2011	MY2010	MY2009	MY2008	MY2007
6	30%	Chassis	Internatonal	4300	4 x 2 DuraStar series 107"		$70,800	$59,100	$52,000	$43,875	$35,775	$28,550	$25,575
		Vocational Bodies			RL waste packer 20 yd	50%	$35,575	$31,515	$28,395	$23,815	$21,165	$18,505	$16,005
					RL waste packer 25 yd	50%	$35,765	$31,720	$28,580	$23,965	$21,300	$18,620	$16,110
8A	50%	Chassis	Mack	GU812	4 x 2 Granite Series 116"		$117,150	$82,875	$69,025	$54,900	$43,925	$34,375	
		Vocational Bodies			RL waste packer 25 yd	50%	$35,765	$31,720	$28,580	$23,965	$21,300	$18,620	
					RL waste packer 30 yd	50%	$38,240	$33,885	$30,530	$25,605	$22,755	$19,895	
8B	20%	Chassis	Kenworth	T800	8 x 4 121" Long Conv		$133,100	$113,350	$97,525	$79,950	$69,725	$60,675	$43,625
		Vocational Bodies			RL waste packer 30 yd	100%	$38,240	$33,885	$30,530	$25,605	$22,755	$19,895	$17,210

WEIGHTED AVERAGE		MY2013	MY2012	MY2011	MY2010	MY2009	MY2008	MY2007
WEIGHTED AVERAGE	CHASSIS ONLY	$106,435	$81,838	$69,618	$56,603	$46,640	$37,888	$16,398
	CHASSIS & BODY	$143,285	$114,501	$99,047	$81,283	$68,575	$57,064	$24,657

[1] Based on analysis of MY2011 - MY2013 trucks in LICENSE fleet as of June 2013
[2] Based on discussions with NYC Business Integrity Commission staff and various fleet operators
[3] Values from TruckBlueBook.com, June 1 - June 30 , 2013; retail price

Table 4 Weighted Average Cost of New and Used CL2 Trucks in 2013

Weight Class	% of Trucks [1]	Equipment	Make	Model	Description	% of Bodies [2]	Purchase Cost in CY2013 [3]						
							MY2013	MY2012	MY2011	MY2010	MY2009	MY2008	MY2007
6	20%	Chassis	Internatonal	4300	4 x 2 DuraStar series 107"		$70,800	$59,100	$52,000	$43,875	$35,775	$28,550	$25,575
		Vocational Bodies			Alum dump body 9-10 cu yd	50%	$14,535	$12,860	$11,255	$9,440	$8,390	$7,335	$6,345
					Roll-off hoists 60,000 lb	50%	$30,985	$30,235	$24,750	$20,755	$18,445	$16,125	$13,950
8A	20%	Chassis	Mack	GU812	4 x 2 Granite Series 116"		$117,150	$82,875	$69,025	$54,900	$43,925	$34,375	$25,781
		Vocational Bodies			Alum dump body 13-14 cu yd	25%	$18,590	$16,745	$14,660	$12,295	$10,925	$9,935	$8,544
					Roll-off hoists 60,000 lb	25%	$30,985	$30,235	$24,750	$20,755	$18,445	$16,125	$13,950
					RL waste packer 25 yd	25%	$35,765	$31,720	$28,580	$23,965	$21,300	$18,620	$16,174
					RL waste packer 30 yd	25%	$38,240	$33,885	$30,530	$25,605	$22,755	$19,895	$17,210
8B	60%	Chassis	Kenworth	T800	8 x 4 121" Long Conv		$133,100	$113,350	$97,525	$79,950	$69,725	$60,675	$43,625
		Vocational Bodies			Alum dump body 15-16 cu yd	33%	$19,890	$19,585	$15,570	$13,055	$11,605	$10,145	$8,775
					Roll-off hoists 60,000 lb	33%	$30,985	$30,235	$24,750	$20,755	$18,445	$16,125	$13,950
					RL waste packer 30 yd	33%	$38,240	$33,885	$30,530	$25,605	$22,755	$19,895	$17,210

WEIGHTED AVERAGE		MY2013	MY2012	MY2011	MY2010	MY2009	MY2008	MY2007
WEIGHTED AVERAGE	CHASSIS ONLY	$117,450	$96,405	$82,720	$67,725	$57,775	$48,990	$36,446
	CHASSIS & BODY	$145,826	$122,917	$105,275	$86,640	$74,585	$63,705	$49,177

[1] Based on analysis of MY2011 - MY2013 trucks in CL2 fleet as of June 2013
[2] Based on discussions with NYC Business Integrity Commission staff and various fleet operators
[3] Values from TruckBlueBook.com, June 1 - June 30 , 2013; retail price

The analysis assumes that for the baseline scenario 80% of the trucks entering the fleet each year would be new and 20% would be used trucks that were two-years old. This mirrors the general buying pattern seen today, based on analysis of fleet data over the past five years.

Because all of the analyzed policy cases would require truck owners to purchase a larger number of trucks each year than they currently do – in order to be able to retire their oldest trucks – the analysis assumes that their buying behavior would change in favor of buying more used trucks and fewer brand new trucks, to reduce their costs. For Policy Cases 2, 3, and 4 the analysis assumes that 50% of the trucks entering the fleet each year would be new, 25% would be two-years old, and 25% would be four years old. Under Policy Case 1 truck owners would need to replace more than 1,000 trucks per year over the next two years, so the analysis assumes that most of these trucks would be used trucks rather than new. Policy Case 1 assumes that in 2014 and 2015 8% of the trucks entering the fleet would be new, 17% would be one or two years old, and 75% would be three to seven years old. After 2015 this scenario assumes that annual truck purchases would be the same as under the baseline scenario.

These estimates of expected buying behavior under the baseline and each policy scenario are best estimates based on available information, including analysis of current fleet data, and anecdotal evidence gathered by discussion with various fleets operators, and they are considered to be conservative.

For Policy Case 3A truck purchases in 2014-2015 are assumed to be the same as under Policy Case 1, while they are assumed to be the same as Policy Case 3 in later years.

2.5 Annual Vehicle Use

Based on an analysis of annual fuel costs supplied to NYCBIC by 84 regulated carting companies that operate over 2,000 trucks, their average annual mileage was approximately 12,000 miles per truck in 2011[10]. This figure is generally consistent with data supplied by a number of the same companies to the Federal Motor Carrier Safety Administration[11].

To calculate annual fleet emissions of PM and NOx this analysis assumes that all trucks in both the License and CL2 fleets will operate, on average, 12,000 miles per year every year between 2013 and 2030. The analysis also assumes that the size of each fleet will remain constant throughout that time period: 4,281 License trucks and 4,065 CL2 trucks. Both of these assumptions are consistent with current conditions, based on best available data.

2.6 Vehicle Maintenance Costs

Based on an analysis of information on truck costs supplied to NYCBIC by 84 regulated carting companies that operate over 2,000 trucks, their average cost of “repairs and maintenance” was $9,582 per truck in 2011.

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[10] Annual fuel use for each fleet (gallons) was determined by dividing total reported fuel costs ($) by the average diesel fuel price ($/gal) in New York, as reported by the U.S. Energy Information Administration. Annual mileage for each fleet was determined by multiplying annual fuel use by average truck fuel economy of 3.7 miles per gallon. Annual mileage per truck was determined by dividing annual fleet mileage by the number of active licensed trucks.

[11] FMCSA Safety and Fitness Electronic Records (SAFER), [http://safer.fmcsa.dot.gov/companysnapshot.aspx]

Anecdotal evidence indicates that in general older trucks have higher average maintenance costs than newer trucks, though the relationship between age and maintenance cost is not linear. As such, a truck age-out requirement that results in a greater number of new trucks in the fleet should reduce over-all maintenance costs for the fleet, which would at least partially offset the additional cost of purchasing the new trucks.

This analysis evaluated the potential maintenance cost savings associated with each policy case by calculating, for each year, the difference in total trucks between zero and five years old compared to the base case. This difference in the number of "newer" trucks was multiplied by $1,425 per truck to calculate the annual maintenance savings associated with having more newer trucks in the fleet due to the policy case. The figure of $1,425 per truck represents a 15% savings compared to the current fleet average maintenance costs. Over the entire analysis period (2013 – 2030) the net present value (2013 dollars) of potential maintenance cost savings was calculated using a 6% discount rate.

3 Results

This section summarizes the results of this analysis, for the baseline business as usual case and all of the policy cases.

3.1 New & Used Truck Purchases

See Figure5 for a summary of the number of new trucks projected to enter the fleet each year under the baseline scenario, and the number of trucks that would need to enter the fleet each year to comply with the age-out requirements of each Policy Case.

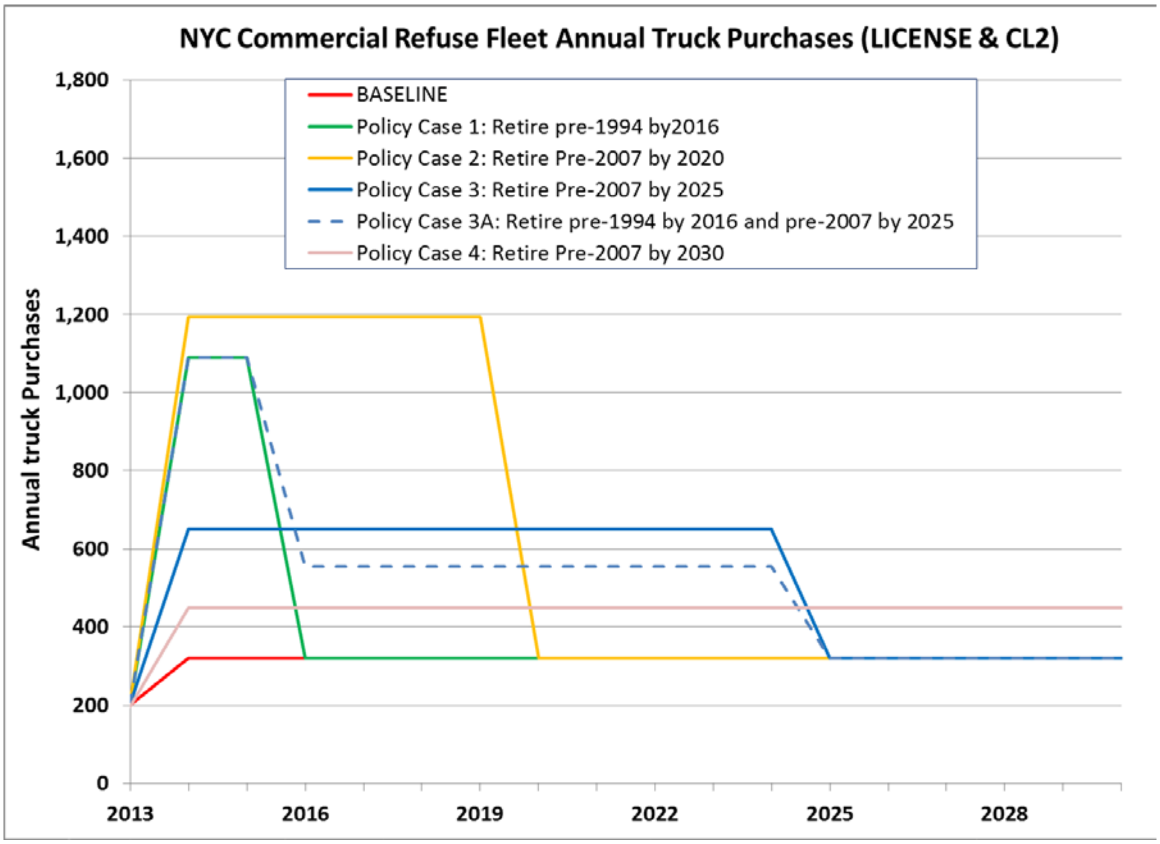

Figure 5 Total Annual Truck Purchases, License and CL2 Fleets

The baseline scenario assumes that 321 new trucks will enter the fleet each year between 2014 and 2030, and that 321 of the oldest trucks will be retired each year – this level of fleet turnover (3.8% per year) is sufficient to maintain a stable average fleet age[12].

[12] For each calendar year average fleet age is calculated by multiplying the number of trucks of each model year by their age in that calendar year, summing the result for all model years in the fleet, and dividing by the total number of trucks. Trucks whose model year is the same as the calendar year are assumed to be zero years old (i.e. MY2013 in CY2013), trucks whose model year is one year prior to the calendar year (i.e. MY 2012 in CY2013) are assumed to be one year old, etc.

Under Policy Case 1, in order to retire all pre-1994 trucks by the beginning of 2016, almost 1,100 older trucks will need to be retired each year in 2014 and 2015, so this number of new (or post-2007 used) trucks will need to be purchased. In later years annual truck purchasing is assumed to be the same as in the baseline scenario (321 trucks per year).

Under Policy Case 2, in order to retire all pre-2007 trucks by the beginning of 2020, 1,200 older trucks will need to be retired each year between 2014 and 2019, so an equivalent number of new or used trucks will need to be purchased each year. In later years annual truck purchasing is assumed to be the same as in the baseline scenario.

Under Policy Case 3, in order to retire all pre-2007 trucks by the beginning of 2025, 651 older trucks will need to be retired each year between 2014 and 2024, so an equivalent number of new or used trucks will need to be purchased each year. In later years annual truck purchasing is assumed to be the same as in the baseline scenario.

Under Policy Case 4, in order to retire all pre-2007 trucks by the beginning of 2030, 448 older trucks will need to be retired each year between 2014 and 2024, so an equivalent number of new or used trucks will need to be purchased each year.

Policy Case 3A combines aspects of Policy Case 1 and Policy Case 3: in 2014 and 2015 1,100 new or used trucks will be purchased each year, between 2016 and 2024 554 new trucks will be purchased each year, and after 2024 321 new and used trucks will be purchased each year.

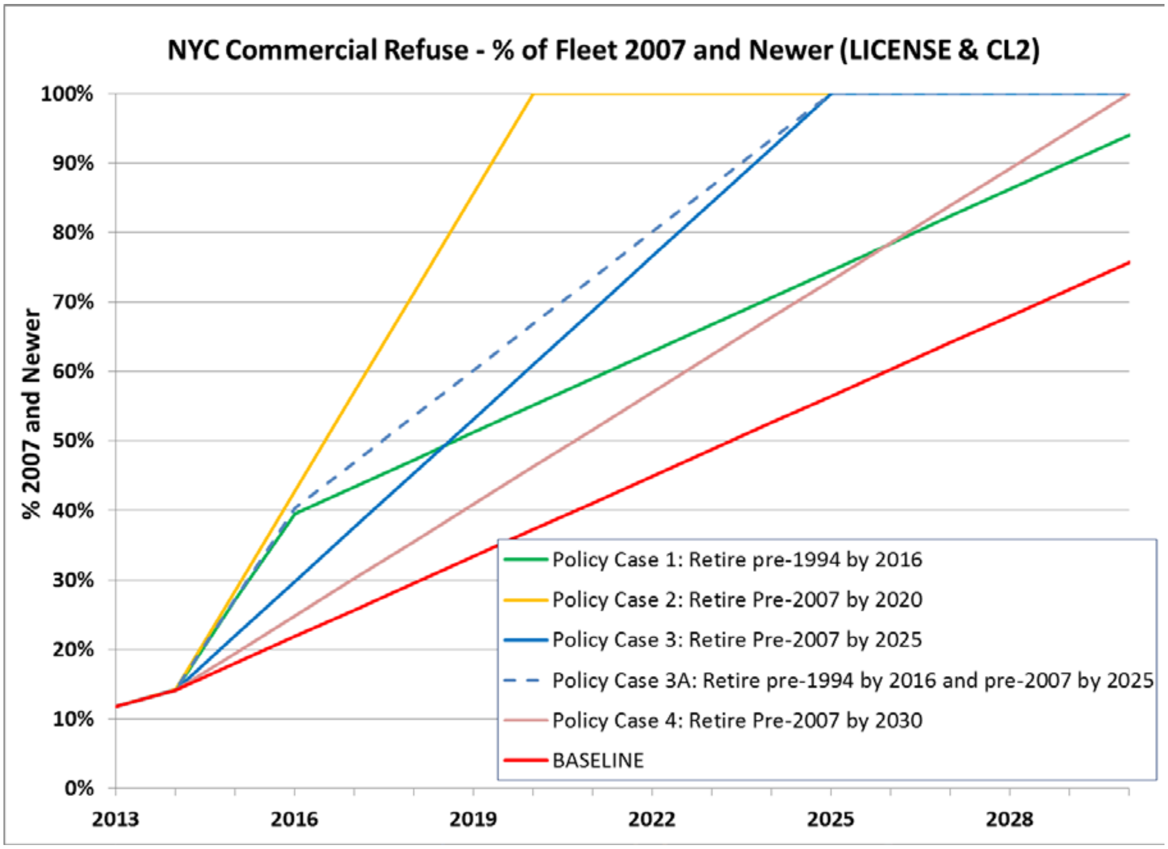

Figure 6 Percentage of Post-2007 Trucks in License and CL2 Fleets

See Figure 6 for a summary of what percentage of the License and CL2 fleets will be the cleanest trucks that meet the most stringent EPA emission standards (model year 2007 and later) under the baseline scenario and each policy case. Under the baseline scenario, by 2030 only 76% of the fleet will be clean trucks. Under Policy Case 1, 94% of the fleet will be clean in 2030, and under Policy Case 4 100% of the fleet will be clean in 2030. Under both Policy Case 3 and Policy Case 3A, 100% of the fleet will be clean as of 2025, and under Policy Case 2 100% of the fleet will be clean as of 2020.

See Figure 7 for a summary of the projected average age of trucks in the License and CL2 fleets under the baseline scenario and each policy case. The baseline scenario assumes that fleet turnover will be just high enough (3.8% per year) to maintain the current average truck age of approximately 15 years old. All of the Policy cases require higher fleet turnover to new trucks, so the average fleet age goes down under each.

Under Policy Case 1 the average truck age drops to 11.5 years old in 2016, and then climbs back up to 13.6 years old by 2030. Under Policy Case 2 the average truck age drops to 5.7 years old in 2020 and then climbs back up to 10.8 years old in 2030. Under Policy Case 2 the average truck age drops to 8.5 years old in 2025 and then climbs back up to 10.3 years old in 2030. Under Policy Case 3A average truck age drops to a low of

9.7 years old in 2025, and then climbs to 11.1 years old in 2030. Under Policy Case 4 the average truck age drops steadily, reaching a low of 11.4 years old in 2030.

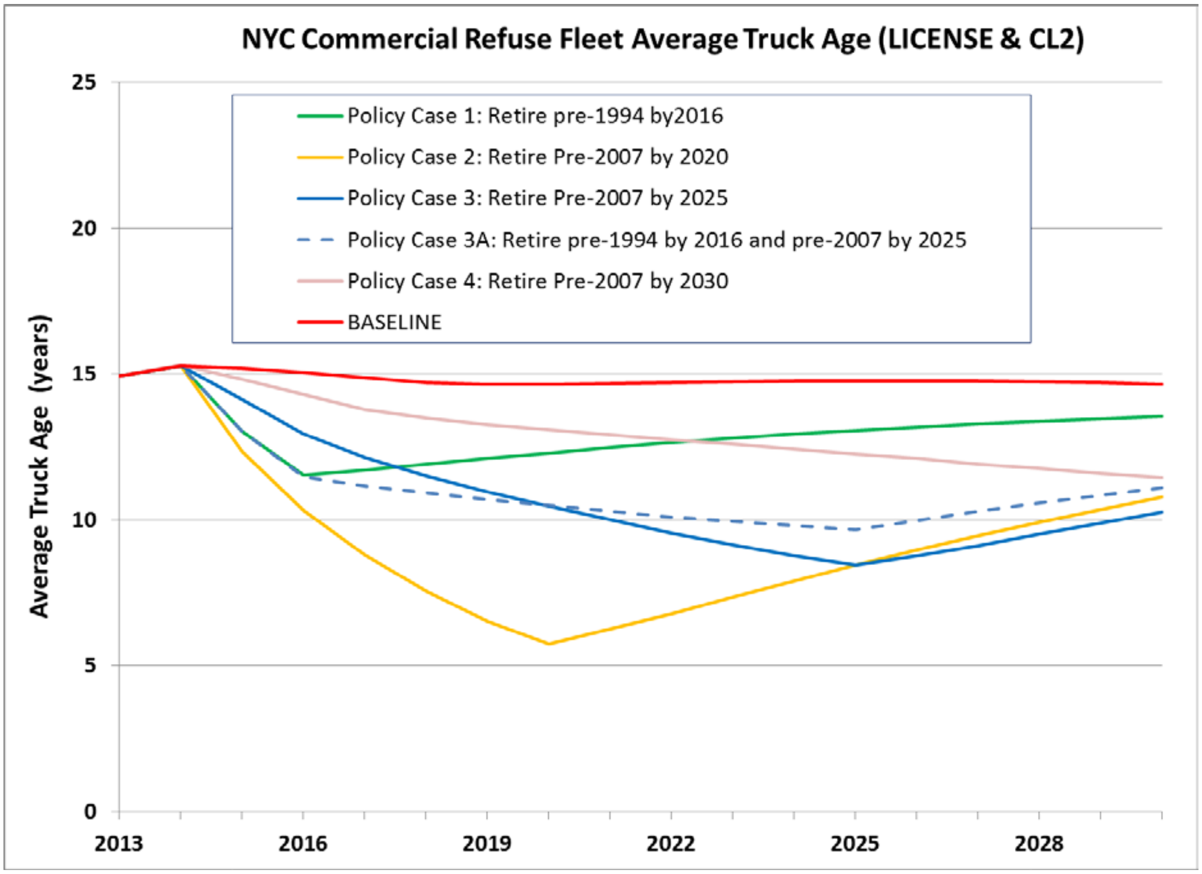

Figure 7 Average Fleet Age of License and CL2 Fleets

3.2 Truck Purchase Costs

See Figure 8 for a summary of the projected total cost to purchase new and used trucks each year for the License and CL2 fleets under the baseline scenario, as well as the total cost to purchase new and used trucks each year under each Policy Case. In this analysis the "cost" attributed to each policy case is the net present value of the difference in annual truck purchase costs between that Policy Case and the baseline scenario, summed over the entire analysis period (2013 – 2030).

Under the baseline scenario total annual truck purchase costs are estimated to be $44.9 million in 2014, and they rise to $72.1 million in 2030 due to inflation (assumed to be 3% per year). For Policy Case 1, total annual truck purchase costs are estimated to be $73.7 million in 2014 and $76 million in 2015, but after that they drop significantly, and are equal to purchase costs in the baseline scenario. For Policy Case 2 total annual truck purchase costs are estimated to average $153 million per year between 2014 and 2019; in later years they are the same as in the baseline scenario. For Policy Case 3 total annual truck purchase costs are estimated to average $92.7 million per year between 2014 and 2024; in later years they are the same as in the baseline scenario. For Policy Case 3A total annual truck purchase costs are estimated to average $81.6 million per year between 2014 and 2024; in later years they are the same as in the baseline scenario. For Policy Case 4, total annual truck purchase costs are estimated to be $53.3 million in 2014, and they rise to $85.5 million in 2030.

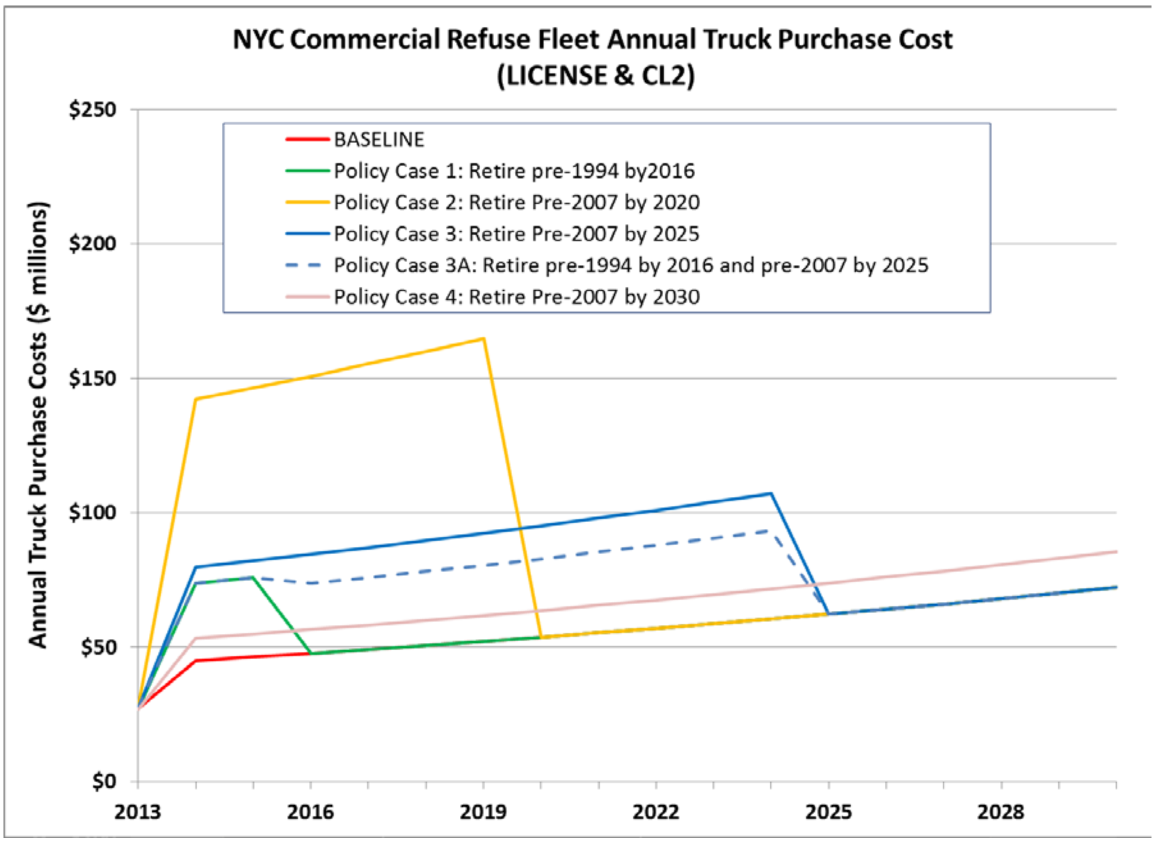

Figure 8 Annual Total Truck Purchase Costs, License and CL2 Fleets

See Table 5 for a summary of the average annual total truck purchasing costs under the baseline scenario and each policy case. As shown, under the baseline scenario between 2013 and 2030 the License and CL2 fleet operators are projected to spend an average of $55.8 million per year to replace trucks. Under Policy Case 1 the average annual cost to replace trucks is projected to be $59.1 million per year, which is $3.2 million per year more than the baseline. Under Policy Case 2 the average annual cost to replace trucks is $50.8 million, which is $5.1 million less than under the baseline scenario; this is because a higher percentage of trucks entering the fleet each year are assumed to be less expensive used trucks rather than new. However, this annual average cost does not account for the time value of money, and the fact that under Policy Case 2 expenditures will need to be made earlier than under the baseline scenario.

Compared to the baseline scenario the incremental average annual cost of truck purchasing under the other policy cases ranges from a low of $10.1 million (Policy Case 4) to a high of $24.7 million (Policy Case 3).

Table 5 Average Annual Truck Purchase Costs, 2013 - 2030 (2013 $)

	Average Annual Truck Purchase Cost ($ millions)	Incremental Average Annual Truck Purchase Cost ($ millions)
Baseline Scenario	$55.8	NA
Policy Case 1	$59.1	$3.2
Policy Case 2	$50.8	($5.1)
Policy Case 3	$80.6	$24.7
Policy Case 3A	$73.8	$17.9
Policy Case 4	$65.9	$10.1

3.3 NOx and PM Emissions

See Figure 9 for a summary of projected annual NOx emissions from the License and CL2 fleets between 2013 and 2030 under the baseline scenario and each policy case. See Figure 10 for a summary of projected annual PM emissions over the same time frame. As shown in Figure 9, over the next seventeen years annual NOx emissions from the commercial hauling fleet are expected to fall from over 2,200 tons in 2013 to just over 500 tons in 2030 (baseline, shown in red) as older trucks are replaced with new trucks. Each of the analyzed Policy Cases will result in significantly lower NOx emissions than the baseline in each year, because they will result in more new, clean trucks and fewer old, dirty trucks in the fleet each year. The most aggressive policy (Policy Case 2 – retire all pre-2007 trucks by 2020) will reduce annual NOx emissions from the fleet to less than 200 tons by 2022.

As shown in Figure 10, the analyzed age-out policies will produce similar, significant reductions in annual PM emissions from the commercial carting fleet. Under Policy Case 2 annual PM emissions will fall to approximately four tons by 2020.

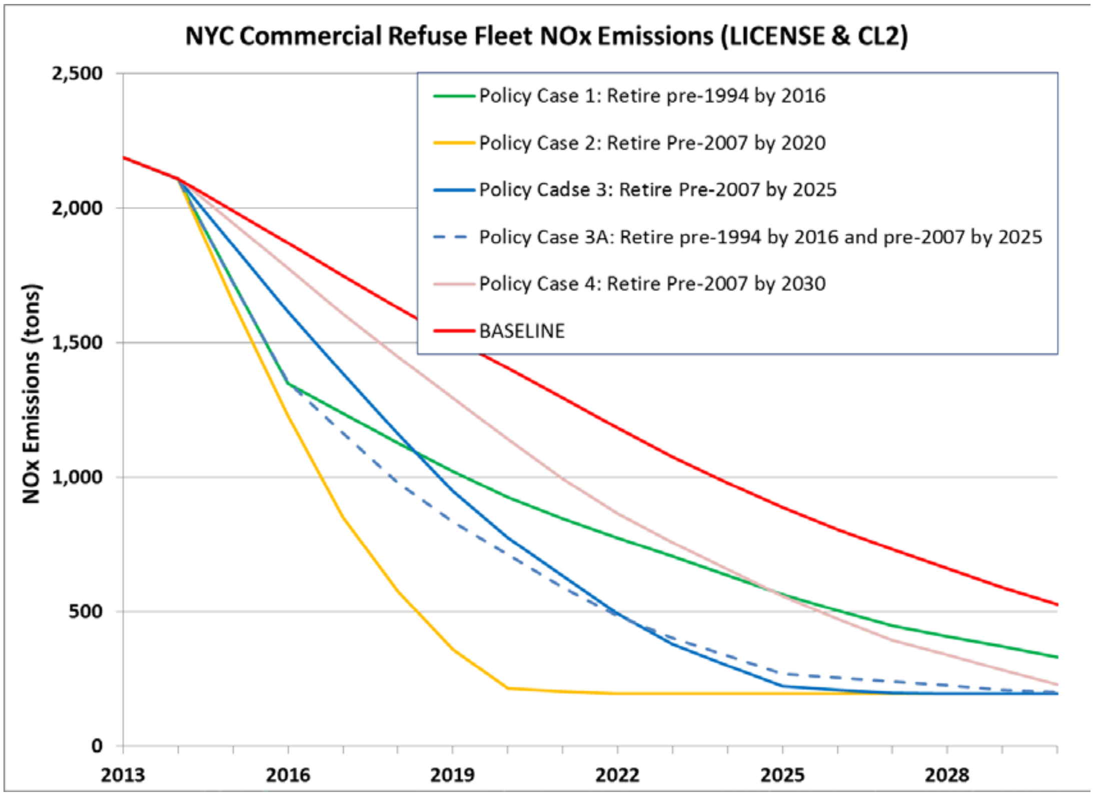

Figure 9 Estimated Annual NOx Emissions from NYC Commercial Refuse Trucks

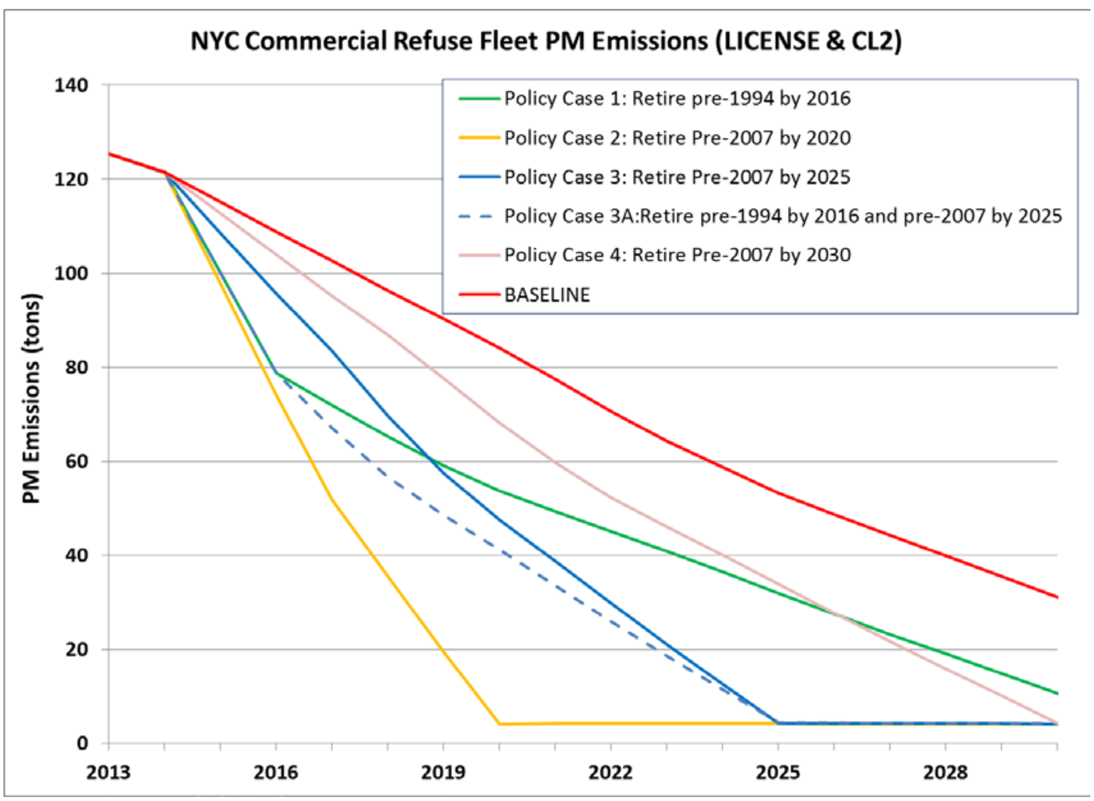

Figure 10 Estimated Annual PM Emissions from NYC Commercial Refuse Trucks

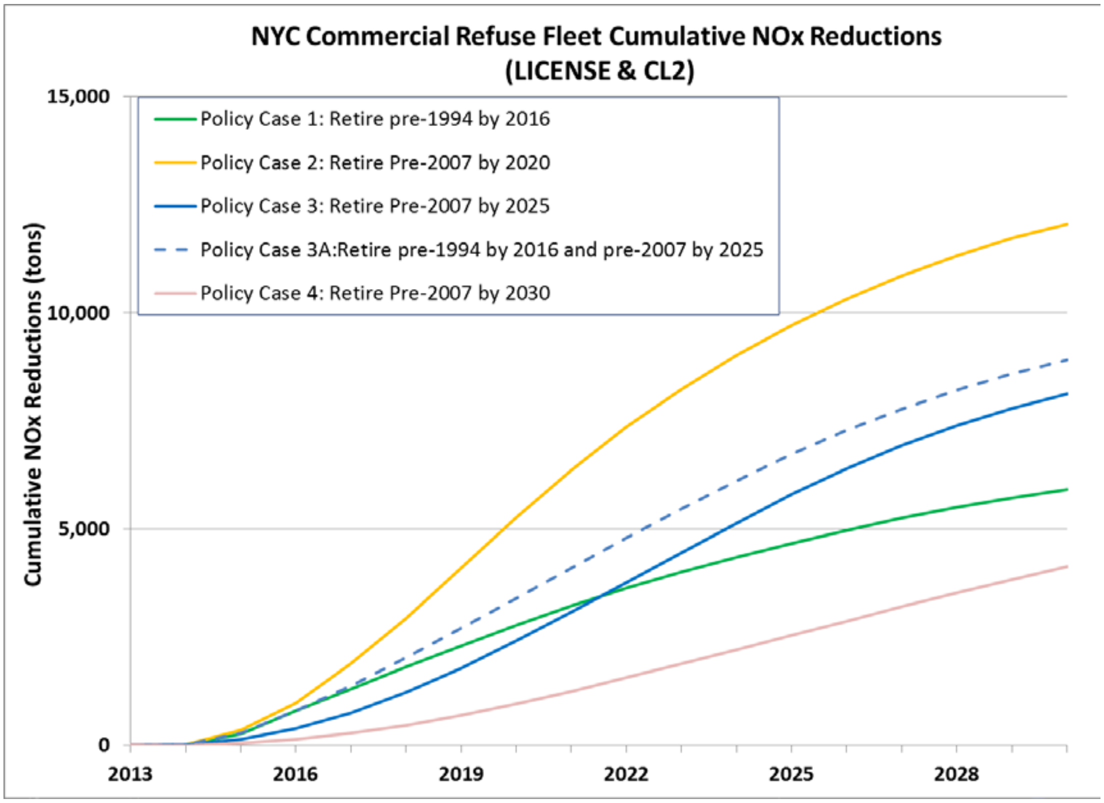

Figure 11 Cumulative NOx Reductions From Analyzed Policy Cases

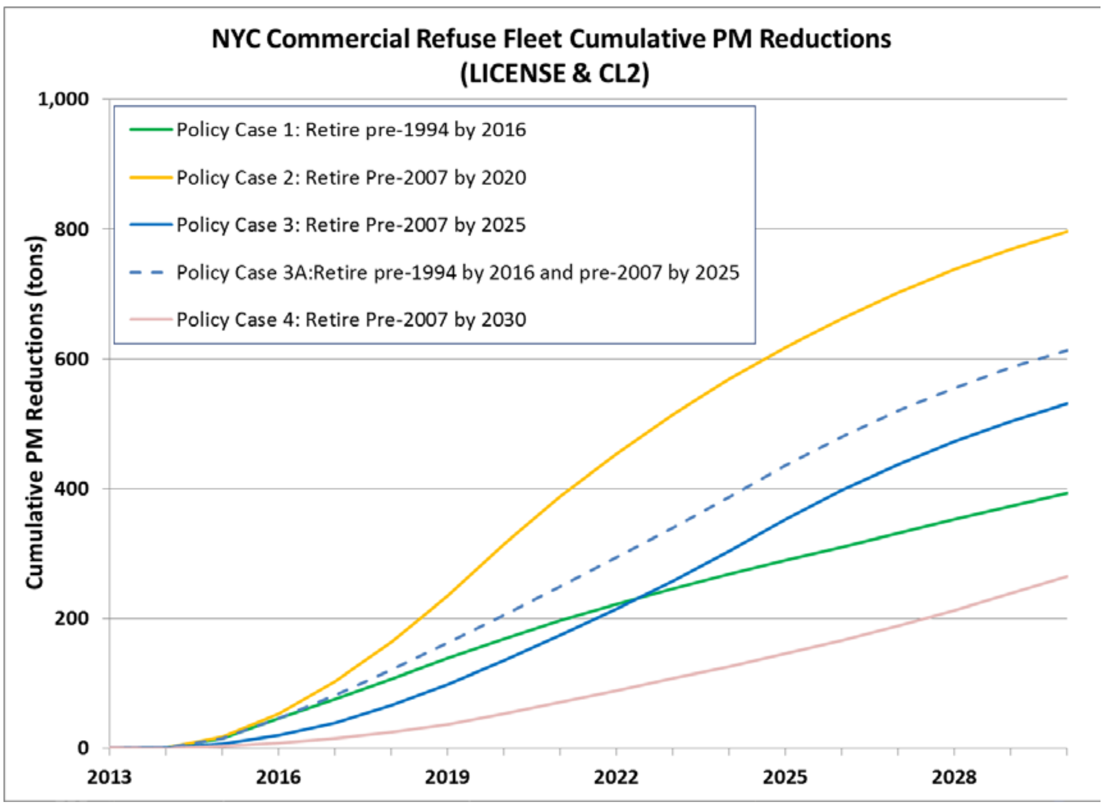

Figure 12 Cumulative PM Reductions From Analyzed Policy Cases

See Figure 11 for a summary of estimated cumulative NOx reductions, relative to the baseline scenario, that will result from faster fleet turnover under reach policy case, and see Figure 12 for a summary of estimated cumulative PM reductions. In each calendar year the cumulative reductions shown are total annual reductions relative to the business as usual baseline that have accrued since 2014 (the beginning of each policy case).

As shown, Policy case 2 provides the greatest benefits relative to the business as usual baseline – by 2030 total cumulative NOx reductions will exceed 12,000 tons and total cumulative PM reductions will exceed 795 tons. Policy Case 4 provides the least benefit - 4,132 tons NOx reduction and 265 tons PM reduction through 2030. Policy Cases 1, 3, and 3A would provide total NOx and PM benefits falling between these extremes.

The average annual reductions in NOx and PM under each policy case are shown in Table 6. As shown, the average annual reductions in NOx emissions range from 243 tons (Policy Case 4) to 709 tons (Policy Case 2). The average annual reductions in PM emissions range from 15.6 tons (Policy Case 4) to 46.8 tons (Policy Case 2).

Table 6 Average Annual Reductions in NOx and PM between 2014 and 2030

	Average Annual NOx Reduction (tons)	Average Annual PM reduction (tons)
Policy Case 1	348.1	23.1
Policy Case 2	709.0	46.8
Policy Case 3	478.0	31.2
Policy Case 3A	524.3	36.1
Policy Case 4	243.0	15.6

3.4 Equivalent Vehicle Reductions

This section of the analysis is intended to provide context for the scale of emission reductions that would result from each of the analyzed policy cases, by determining how many vehicles of various other vehicle types would need to be permanently removed from the road to provide an equivalent emission reduction – i.e. "in terms of reduced PM emissions, implementing Policy Case 1 would be like removing X taxis from New York City's streets".

To calculate an equivalent number of vehicles, the estimated average annualized emission reductions from each policy case were divided by the estimated annual emissions from a vehicle of each vehicle type. For each vehicle type annual emissions of NOx and PM were estimated using equation 1:

$$\text{Annual Emissions (g)} = \text{Emission Factor (g/mi)} \times \text{Annual Usage (mi)}$$

Equation 1

For each vehicle type emission factors were taken from EPA's MOVES emissions model. Separate emission factors were determined for Model Year 2014 vehicles in calendar year 2014 (representing a "new vehicle") and for the average of all vehicles in the fleet in calendar year 2014 (representing an older, "average vehicle"). Various sources were used to estimate the average annual usage of each type of vehicle, including the Department of Energy's Transportation Energy Data Book, the New York City Taxi Fact Book, and the National Transit Database, and the 2011 Motor Coach Census.

Table 7 Estimated Annual Emissions of PM and NOx from Various Vehicle Types

Vehicle		Annual Usage[1]	Emissions Rate[2] [g/mi]		Annual Emissions [lbs]	
Type	Age	[miles]	PM	NOx	PM	NOx
Average Car	MY2014	12,427	0.01	0.06	0.27	1.64
	CY2014 Fleet Average	12,427	0.01	0.36	0.27	9.86
Average Light truck (<6,000 lb)	MY2014	10,278	0.01	0.22	0.23	4.98
	CY2014 Fleet Average	10,278	0.03	1.04	0.68	23.57
NYC Taxi	MY2014	37,686	0.01	0.06	0.83	4.98
	CY2014 Fleet Average	37,686	0.01	0.36	0.83	29.91
Light Commercial Truck	MY2014	13,239	0.01	0.37	0.29	10.80
	CY2014 Fleet Average	13,239	0.04	1.43	1.17	41.74
Medium Duty Commercial Truck	MY2014	13,239	0.01	1.48	0.29	43.20
	CY2014 Fleet Average	13,239	0.13	3.77	3.79	110.03
Tractor Trailer Truck	MY2014	66,759	0.02	1.28	2.94	188.39
	CY2014 Fleet Average	66,759	0.44	8.50	64.76	1,251.00
Intercity Coach Bus	MY2014	54,900	0.03	1.25	3.63	151.29
	CY2014 Fleet Average	54,900	0.65	11.63	78.67	1,407.60
NYC Transit Bus	MY2014	26,028	0.01	1.07	0.57	61.40
	CY2014 Fleet Average	26,028	0.03	8.84	1.72	507.25

[1] U.S. Average car and light truck: Transportation Energy Databook, Edition 32, 2013, Table 4.1 and 4.2; data for 2011
NYC taxi: The New York City Taxi Cab Fact Book, Schaller Consulting, 2006; 172 million trips x 2.8 mi/trip ÷ 12,779 licenced taxis; data for 2005
Light, medium commercial truck and Tractor-trailer truck: Transportation Energy Databook, Edition 32, 2013, Table 5.1 and 5.2; data for 2011
Intercity Coach Bus: 2011 Motor Coach Census, American Bus Association Foundation; data for 2010
NYC Transit Bus: National Transit Database, 2011; data is for 2011

[2] Emission factors from EPA MOVES model. Factors for commercial trucks assume short-haul trucks. Fleet average PM emission factors for NYC Transit buses assume all buses are retrofit with DPF.

See Table 7 for a summary of estimated annual emissions from each vehicle type and Table 8 for a summary of the number of vehicles of each type that would be equivalent to the estimated emission reductions from the different policy cases.

As shown, for example, the average annual PM emission reductions that would result from Policy Case 1 would be equivalent to removing 168,846 cars from the roads of New York City every year between 2014 and 2030. The NOx emission reductions that would result from Policy Case 1 would be equivalent to removing an average of 70,596 old cars (CY2014 fleet average) or 423,576 new cars (MY2014) from the roads.

Table 8 Commercial Refuse Truck Age-out Policy Case Vehicle Equivalents

Vehicle Type	Vehicle Age	Average Annual PM reductions from 2014 - 2030 are equivalent to removing this many vehicles from the road: Policy Case 1	Policy Case 2	Policy Case 3	Policy Case 3A	Policy Case 4
Average Car	MY2014	168,846	341,829	228,098	263,408	113,673
	CY2014 Fleet Average	168,846	341,829	228,098	263,408	113,673
Average Light truck (<6,000 lb)	MY2014	204,150	413,302	275,790	318,484	137,440
	CY2014 Fleet Average	68,050	137,767	91,930	106,161	45,813
NYC Taxi	MY2014	55,677	112,719	75,216	86,859	37,484
	CY2014 Fleet Average	55,677	112,719	75,216	86,859	37,484
Light Commercial Truck	MY2014	158,490	320,864	214,108	247,253	106,701
	CY2014 Fleet Average	39,623	80,216	53,527	61,813	26,675
Medium Duty Commercial Truck	MY2014	158,490	320,864	214,108	247,253	106,701
	CY2014 Fleet Average	12,192	24,682	16,470	19,019	8,208
Tractor Trailer Truck	MY2014	15,715	31,815	21,230	24,516	10,580
	CY2014 Fleet Average	714	1,446	965	1,114	481
Intercity Coach Bus	MY2014	12,740	25,792	17,211	19,875	8,577
	CY2014 Fleet Average	588	1,190	794	917	396
NYC Transit Bus	MY2014	80,615	163,206	108,905	125,764	54,273
	CY2014 Fleet Average	26,872	54,402	36,302	41,921	18,091

Vehicle Type	Vehicle Age	Average Annual NOx reductions from 2014 - 2030 are equivalent to removing this many vehicles from the road: Policy Case 1	Policy Case 2	Policy Case 3	Policy Case 3A	Policy Case 4
Average Car	MY2014	423,576	862,704	581,529	637,960	295,696
	CY2014 Fleet Average	70,596	143,784	96,921	106,327	49,283
Average Light truck (<6,000 lb)	MY2014	139,675	284,478	191,760	210,368	97,506
	CY2014 Fleet Average	29,547	60,178	40,565	44,501	20,626
NYC Taxi	MY2014	139,675	284,478	191,760	210,368	97,506
	CY2014 Fleet Average	23,279	47,413	31,960	35,061	16,251
Light Commercial Truck	MY2014	64,475	131,318	88,518	97,108	45,010
	CY2014 Fleet Average	16,682	33,977	22,903	25,126	11,646
Medium Duty Commercial Truck	MY2014	16,119	32,829	22,130	24,277	11,252
	CY2014 Fleet Average	6,328	12,888	8,687	9,530	4,417
Tractor Trailer Truck	MY2014	3,696	7,528	5,074	5,567	2,580
	CY2014 Fleet Average	557	1,134	764	838	389
Intercity Coach Bus	MY2014	4,602	9,373	6,318	6,932	3,213
	CY2014 Fleet Average	495	1,007	679	745	345
NYC Transit Bus	MY2014	11,340	23,097	15,569	17,080	7,917
	CY2014 Fleet Average	1,373	2,796	1,884	2,067	958

PM emission reductions from Policy Case 1 would be equivalent to removing 158,490 new or 12,192 old medium-duty commercial trucks from New York City streets, while the NOx reductions from Policy Case 1 would be equivalent to removing 16,119 new or 6,328 old medium-duty commercial trucks.

Vehicle equivalent values for the larger vehicles – tractor trailer trucks and buses – are lower because these vehicles have, on average, higher annual emissions.

Vehicle equivalent values for each vehicle type are higher for the other policy options than for policy option 1, in proportion to estimated emission reductions from these policy options.