CHAPTER 8: Estimated Aggregate Cost and Cost per Ton of Reduced Emissions

CHAPTER 8: Estimated Aggregate Cost and Cost per Ton of Reduced Emissions

Our estimate of fixed and variable costs for new nonroad engines and equipment compliant with today's proposal are detailed in Chapter 6. Chapter 6 also contains a discussion of the operating savings and costs expected to result from the new low sulfur diesel fuels available to nonroad engines, locomotive engines, and marine engines. Our estimates of the costs to meet the proposed nonroad diesel fuel requirements can be found in Chapter 7. This chapter contains information on how the incremental costs for engines, the incremental operating costs, the incremental equipment costs, and the incremental fuel costs are aggregated to estimate the cost of the proposed program. The detailed information on the calculation for the cost per ton per pollutant is also included in this Chapter.

We have calculated the cost per ton of our proposed program based on the net present value of all costs incurred and all emission reductions generated over a 30 year time window following implementation of the program. This approach captures all of the costs and emissions reductions from our proposed program including those costs incurred and emissions reductions generated by the existing fleet. The baseline (i.e., the point of comparison) for this evaluation is the existing set of fuel and engine standards (i.e., unregulated fuel and the Tier 2/Tier 3 program). The 30 year time window chosen is meant to capture both the early period of the program when very few new engines that meet the proposed standards would be in the fleet, and the later period when essentially all engines would meet the proposed standards. Note that all costs and emission reductions presented here are 30 year numbers (net present values are 2007 through 2036, expressed in 2004). Elsewhere in this draft RIA we use numbers through 2030 (i.e., 2007 through 2030, expressed in 2004). As a result, net present values presented here will differ from net present values in other sections of this draft RIA.

8.1 Projected Sales and Cost Allocations

Projected nonroad engine and equipment sales estimates are used in several portions of this analysis. We have used two sources for our projected sales numbers – the PSR database for the 2000 model year, and our Nonroad Model.[1, 2] The PSR database has been used as the basis for our current fleet mix – i.e., what equipment types were sold in 2000 and with what horsepower engines. The sales estimates and growth rates used throughout this analysis are shown in Table 8.1-1.[3]

Table 8.1-1
Estimated 2000 Engine Sales and Future Sales Growth

Horsepower Range	2000 Model Year Sales	Annual Growth in Engines Sold	Linear Growth Rate
0<hp<25	119,159	4,116	3.7%
25≤hp<50	132,981	3,505	2.8%
50≤hp<75	93,914	2,046	2.3%
75≤hp<100	68,665	1,499	2.3%
100≤hp<175	112,340	2,321	2.2%
175≤hp<300	61,851	1,414	2.4%
300≤hp<600	34,095	436	1.3%
600≤hp≤750	2,752	50	1.9%
hp>750	2,785	51	1.9%
Total	628,542	15,438	2.5%

Because our proposed program would result in reductions in a number of important pollutants (i.e., NOx, PM, NMHC, and SOx), we have attempted to identify what costs are associated with what pollutant reductions. This apportionment of costs by pollutant allows us to calculate the average cost per ton of emission reduction that would be realized by this program. Deciding how to apportion costs can be difficult even in the case of technologies that, on the surface, seem to have an obvious split by which their costs should be attributed. For instance, we have apportioned 100 percent of the cost for CDPF technology to PM even though CDPFs are expected to reduce NMHC emissions significantly. Similary, we have apportioned 100 percent of the 500 ppm fuel program to SOx control even though it would also provide a significant PM reduction. In our proposed fuel program, the cost for reducing sulfur from uncontrolled levels to 15 ppm are apportioned to NOx+NMHC and PM because the 15 ppm sulfur level has been selected based on the needs of the control technology (i.e., NOx adsorber and CDPF). We have done this even though a significant SOx reduction would also be realized by the new 15 ppm fuel. We have noted throughout our discussion to which pollutant we have attributed costs, and Table 8.1-2 presents a summary of these allocations.

Table 8.1-2.
Summary of How Cost are Allocated Among Pollutants

Item		NOx+ NMHC	PM	SOx
Fuel Costs – incremental cent/gallon	3000 to 500 ppm fuel			100%
	3000 to 15 ppm fuel	50%	50%	
Operating Costs – Oil Change Savings	500 ppm fuel			100%
	15 ppm fuel	50%	50%	
Operating Costs – CDPF Maintenance	15 ppm fuel		100%	
Operating Costs – CDPF Regen (FE impact)	15 ppm fuel		100%	
Operating Costs – CCV Maintenance	2008+	50%	50%	
Engine Variable Costs	CDPF System		100%	
	NOx Adsorber System	100%		
	DOC		100%	
	Fuel Injection System	50%	50%	
	Regeneration System		100%	
	Cooled EGR	100%		
	Closed Crankcase Ventilation Sys	50%	50%	
Engine Fixed Costs – R&D	CDPF+NOx Adsorber	67%	33%	
	CDPF-only		100%	
	DOC-only		100%	
Engine Fixed Costs – Tooling	CDPF+NOx Adsorber	50%	50%	
	CDPF-only		100%	
	DOC-only		100%	
	Cooled EGR	100%		
Engine Fixed Costs – Certification	>75 hp	50%	50%	
	<75 hp 2008		100%	
	50-75 hp 2013		100%	
	25-50 hp 2013	50%	50%	
Equipment Variable Costs	>75 hp	50%	50%	
	<75 hp		100%	
Equipment Fixed Costs – Redesign	2008 standards		100%	
	2011, 2012, 2013 standards	50%	50%	
Equipment Fixed Costs – Operator Manuals	2008 standards		100%	
	2011, 2012, 2013 standards	50%	50%	

8.2 Aggregate Engine Costs

This section presents aggregate engine fixed costs (recovered costs) and variable costs. These costs were discussed in detail in Section 6.2.

8.2.1 Aggregate Engine Fixed Costs

In Chapter 6, Tables 6.2-4, 6.2-6, and 6.2-8 presented the aggregate engine fixed costs,[A] along with our best estimate of how those costs might be recovered (i.e., on what engines), for engine R&D, tooling, and certification, respectively. Table 8.2-1 presents the combined total of all engine fixed costs in the each of the indicated years and also shows to what pollutant these costs are attributed. Note that the cost allocations shown in Table 8.2-1 are not generated assuming any simple split of costs between NOx and PM control. Some engine fixed costs are solely attributed to PM control (e.g., costs associated with the proposed 2008 standards and costs associated with the proposed 2013 standards for 50 to 75 horsepower engines). Therefore, the costs presented in Table 8.2-1 for PM would not represent the total fixed costs of the program if there were no new NOx standards; the same is true of NOx costs if there were no new PM standards. Refer to Section 6.2 for detail on how we have estimated engine fixed costs and their recovery, and to Table 8.1-2 for how they are allocated among each pollutant.

[A] We have estimated a "recovered" cost for all engine and equipment fixed costs to present a per unit analysis of the cost of the proposal. In general, in environmental economics, it would be more conventional to simply count the total cost of the program (i.e., opportunity costs) in the year they occur. However, this approach would not directly estimate a per unit cost since fixed costs occur prior to implementation of the standards and, therefore, there are not yet any units certified as complying with the new standards to which the fixed costs can be attributed. As a result, we grow fixed costs until they can be "recovered" on complying units. Note that the approach used here results in a higher estimate of the total costs of the program since the recovered costs include a seven percent rate of return to the manufacturer.

Table 8.2-1
Aggregate Engine Fixed Costs (millions)

Year	Recovery of PM Costs	Recovery of NOx+NMHC Costs	Recovery of Fixed Costs
2004	$0.0	$0.0	$0.0
2005	$0.0	$0.0	$0.0
2006	$0.0	$0.0	$0.0
2007	$0.0	$0.0	$0.0
2008	$17.4	$0.0	$17.4
2009	$17.4	$0.0	$17.4
2010	$17.4	$0.0	$17.4
2011	$31.9	$14.7	$46.6
2012	$37.1	$19.9	$57.0
2013	$36.9	$21.2	$58.0
2014	$37.1	$35.2	$72.3
2015	$37.1	$35.2	$72.3
2016	$22.6	$20.5	$43.1
2017	$17.4	$15.3	$32.7
2018	$0.2	$14.0	$14.2
2019	$0.0	$0.0	$0.0
2020	$0.0	$0.0	$0.0
Total	$272.3	$175.9	$448.3
NPV 2004-2036	$210.7	$129.5	$340.2

We have assumed that all engine R&D expenditures occur over a five year span preceding the first year any emission control device is introduced into the market. Where a phase-in exists (e.g., for NOx standards on >75 horsepower engines), expenditures are assumed to occur over the five year span preceding the first year NOx adsorbers would be introduced, and then to continue during the phase-in years; the expenditures would be incurred in a manner consistent with the phase-in of the standard. All R&D expenditures are then recovered by the engine manufacturer over an identical time span following the introduction of the technology. We assume a seven percent rate of return for all R&D to reflect the time value of money.

We have assumed that all tooling and certification costs are incurred one year in advance of the new standard and are recovered over a five year period following implementation of the new standard; all tooling costs include a seven percent rate of return to reflect the time value of money.

We have calculated the net present value of the engine fixed costs over the 30 year period following implementation of the program as $340 million. This value assumes a three percent social discount rate and a 2004 date for promulgation of the final standards.

8.2.2 Aggregate Engine Variable Costs

Engine variable costs are discussed in detail in Section 6.2.2 of this Draft RIA. As explained there, we have generated cost estimation equations to calculate engine variable costs. These cost estimation equations are summarized in Table 6.4-2. Using these equations, we have calculated the engine variable costs during the years 2008 through 2036 as shown in Tables 8.2-2 and 8.2-3 (refer to Table 8.1-2 for how costs have been allocated to PM and NOx). Because of their nature, variable costs vary with sales. We have calculated the net present value of the variable costs over the 30 year period following implementation of the program (2007 through 2036) as $13.9 billion. This value assumes a three percent social discount rate.

Table 8.2-2
Aggregate Engine Variable Costs by Horsepower Category (millions)

Year	0<hp<25	25<=hp<50	50<=hp<75	75<=hp<100	100<=hp<175	175<=hp<300	300<=hp<600	600<=hp<=750	>750hp	Total
2004	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2005	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2006	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2007	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2008	$0.0	$24.0	$18.8	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$62.8
2009	$20.5	$24.6	$19.2	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$64.2
2010	$20.0	$23.7	$18.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$62.1
2011	$20.5	$24.2	$18.7	$0.0	$0.0	$157.1	$106.5	$17.1	$18.8	$362.9
2012	$21.0	$24.7	$19.1	$99.7	$197.6	$160.0	$107.7	$17.4	$19.1	$666.2
2013	$21.5	$152.2	$101.8	$101.4	$200.9	$126.2	$84.3	$13.6	$15.3	$817.2
2014	$22.0	$155.2	$103.5	$102.1	$200.4	$161.9	$107.3	$17.4	$31.0	$900.8
2015	$22.5	$84.9	$80.0	$103.9	$203.6	$164.7	$108.4	$17.6	$31.4	$817.1
2016	$23.0	$122.4	$81.3	$105.6	$206.8	$167.5	$109.6	$17.9	$31.9	$866.0
2017	$23.5	$124.6	$82.6	$107.3	$210.0	$170.3	$110.8	$18.1	$32.3	$879.6
2018	$24.1	$126.9	$83.9	$109.0	$213.3	$173.2	$111.9	$18.4	$32.8	$893.3
2019	$24.6	$129.2	$85.2	$110.7	$216.5	$176.0	$113.1	$18.6	$33.2	$907.0
2020	$25.1	$131.4	$86.5	$112.4	$219.7	$178.8	$114.3	$18.9	$33.7	$920.7
2021	$25.6	$133.7	$87.9	$114.1	$222.9	$181.6	$115.4	$19.1	$34.1	$934.4
2022	$26.1	$136.0	$89.2	$115.8	$226.1	$184.4	$116.6	$19.4	$34.6	$948.1
2023	$26.6	$138.2	$90.5	$117.5	$229.3	$187.2	$117.8	$19.6	$35.0	$961.7
2024	$27.1	$140.5	$91.8	$119.2	$232.5	$190.0	$118.9	$19.9	$35.5	$975.4
2025	$27.6	$142.8	$93.1	$120.9	$235.7	$192.8	$120.1	$20.1	$35.9	$989.1
2026	$28.2	$145.0	$94.4	$122.6	$239.0	$195.6	$121.2	$20.4	$36.4	$1,002.8
2027	$28.7	$147.3	$95.7	$124.4	$242.2	$198.4	$122.4	$20.6	$36.8	$1,016.5
2028	$29.2	$149.6	$97.0	$126.1	$245.4	$201.2	$123.6	$20.9	$37.3	$1,030.2
2029	$29.7	$151.8	$98.4	$127.8	$248.6	$204.0	$124.7	$21.1	$37.7	$1,043.9
2030	$30.2	$154.1	$99.7	$129.5	$251.8	$206.8	$125.9	$21.4	$38.2	$1,057.5
2031	$30.7	$156.4	$101.0	$131.2	$255.0	$209.6	$127.1	$21.7	$38.6	$1,071.2
2032	$31.2	$158.7	$102.3	$132.9	$258.2	$212.4	$128.2	$21.9	$39.1	$1,084.9
2033	$31.7	$160.9	$103.6	$134.6	$261.4	$215.2	$129.4	$22.2	$39.5	$1,098.6
2034	$32.3	$163.2	$104.9	$136.3	$264.6	$218.0	$130.6	$22.4	$40.0	$1,112.3
2035	$32.8	$165.5	$106.2	$138.0	$267.9	$220.8	$131.7	$22.7	$40.4	$1,126.0
2036	$33.3	$167.7	$107.6	$139.7	$271.1	$223.6	$132.9	$22.9	$40.9	$1,139.6
NPV 2004-2036	$424.2	$1,983.0	$1,327.5	$1,652.8	$3,228.6	$2,734.7	$1,730.6	$287.8	$487.5	$13,874.3

Table 8.2-3
Aggregate Engine Variable Costs by Technology and by Pollutant (millions)

Year	Fuel System	Cooled EGR	CCV	DOC	CDPF System	CDPF Regen System	NOx Adsorber System	Total PM Costs	Total NOx+NMHC Costs	Total Costs
2004	$0.0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2005	$0.0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2006	$0.0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2007	$0.0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2008	$0.0	$0.0	$0.6	$62.2	$0.0	$0.0	$0.0	$62.5	$0.3	$62.8
2009	$0.0	$0.0	$0.6	$63.6	$0.0	$0.0	$0.0	$63.9	$0.3	$64.2
2010	$0.0	$0.0	$0.5	$61.7	$0.0	$0.0	$0.0	$61.9	$0.2	$62.1
2011	$0.0	$1.2	$7.2	$63.0	$186.0	$28.9	$76.6	$282.1	$80.8	$362.9
2012	$0.0	$1.2	$13.8	$64.3	$361.2	$72.6	$153.0	$505.7	$160.5	$666.2
2013	$55.0	$18.3	$12.1	$21.5	$435.4	$134.4	$140.5	$634.0	$183.2	$817.2
2014	$56.0	$19.6	$10.7	$22.0	$408.3	$126.7	$257.5	$600.2	$300.6	$900.8
2015	$43.0	$15.4	$10.9	$22.5	$387.0	$76.8	$261.5	$521.0	$296.1	$817.1
2016	$43.7	$15.7	$11.0	$23.0	$393.1	$113.9	$265.5	$565.3	$300.7	$866.0
2017	$44.5	$16.0	$11.2	$23.5	$399.2	$115.8	$269.5	$574.4	$305.3	$879.6
2018	$45.3	$16.2	$11.4	$24.1	$405.3	$117.7	$273.4	$583.4	$309.9	$893.3
2019	$46.0	$16.5	$11.5	$24.6	$411.4	$119.5	$277.4	$592.5	$314.5	$907.0
2020	$46.8	$16.8	$11.7	$25.1	$417.5	$121.4	$281.4	$601.6	$319.1	$920.7
2021	$47.6	$17.1	$11.9	$25.6	$423.6	$123.3	$285.4	$610.7	$323.7	$934.4
2022	$48.3	$17.4	$12.0	$26.1	$429.7	$125.1	$289.4	$619.8	$328.3	$948.1
2023	$49.1	$17.6	$12.2	$26.6	$435.8	$127.0	$293.4	$628.9	$332.9	$961.7
2024	$49.9	$17.9	$12.4	$27.1	$441.9	$128.9	$297.4	$638.0	$337.5	$975.4
2025	$50.6	$18.2	$12.5	$27.6	$448.0	$130.8	$301.4	$647.1	$342.1	$989.1
2026	$51.4	$18.5	$12.7	$28.2	$454.0	$132.6	$305.3	$656.1	$346.7	$1,002.8
2027	$52.2	$18.8	$12.9	$28.7	$460.1	$134.5	$309.3	$665.2	$351.3	$1,016.5
2028	$53.0	$19.1	$13.0	$29.2	$466.2	$136.4	$313.3	$674.3	$355.8	$1,030.2
2029	$53.7	$19.3	$13.2	$29.7	$472.3	$138.3	$317.3	$683.4	$360.4	$1,043.9
2030	$54.5	$19.6	$13.4	$30.2	$478.4	$140.1	$321.3	$692.5	$365.0	$1,057.5
2031	$55.3	$19.9	$13.5	$30.7	$484.5	$142.0	$325.3	$701.6	$369.6	$1,071.2
2032	$56.0	$20.2	$13.7	$31.2	$490.6	$143.9	$329.3	$710.7	$374.2	$1,084.9
2033	$56.8	$20.5	$13.9	$31.7	$496.7	$145.7	$333.3	$719.8	$378.8	$1,098.6
2034	$57.6	$20.8	$14.0	$32.3	$502.8	$147.6	$337.2	$728.9	$383.4	$1,112.3
2035	$58.3	$21.0	$14.2	$32.8	$508.9	$149.5	$341.2	$737.9	$388.0	$1,126.0
2036	$59.1	$21.3	$14.4	$33.3	$515.0	$151.4	$345.2	$747.0	$392.6	$1,139.6
NPV 2004-2036	$678.2	$244.2	$182.8	$620.3	$6,336.7	$1,788.2	$4,023.8	$9,297.9	$4,576.4	$13,874.3

8.3 Aggregate Equipment Costs

This section aggregates the amortized fixed and variable cost for equipment estimated in Section 6.3.

8.3.1 Aggregate Equipment Fixed Costs

In Table 6.3-4 we presented the aggregate equipment fixed costs, along with our best estimate of how those costs might be recovered, for equipment redesign and revisions to product literature. Table 8.3-1 presents aggregate equipment fixed costs and also shows to what pollutant these costs are attributed. Note that the cost allocations shown in Table 8.3-1 are not generated assuming any simple split of costs between NOx and PM control. Some equipment fixed costs are solely attributed to PM control (e.g., costs associated with the proposed 2008 standards and costs associated with the proposed 2013 standards for 50 to 75 horsepower engines). Therefore, the costs presented in Table 8.3-1 for PM would not represent the total fixed costs of the program if there were no new NOx standards; the same is true of NOx costs if there were no new PM standards. Refer to Section 6.3 for detail on how we have estimated equipment fixed costs and their recovery, and to Table 8.1-2 for how they are allocated among each pollutant.

Table 8.3-1
Aggregate Equipment Fixed Costs (millions)

Year	Recovery of PM Costs	Recovery of NOx+NMHC Costs	Recovery of Fixed Costs
2004	$0.0	$0.0	$0.0
2005	$0.0	$0.0	$0.0
2006	$0.0	$0.0	$0.0
2007	$0.0	$0.0	$0.0
2008	$4.9	$0.0	$4.9
2009	$4.9	$0.0	$4.9
2010	$4.9	$0.0	$4.9
2011	$26.1	$21.2	$47.3
2012	$39.8	$34.9	$74.7
2013	$49.1	$34.9	$84.1
2014	$58.5	$44.3	$102.8
2015	$58.5	$44.3	$102.8
2016	$58.5	$44.3	$102.8
2017	$58.5	$44.3	$102.8
2018	$53.6	$44.3	$98.0
2019	$53.6	$44.3	$98.0
2020	$53.6	$44.3	$98.0
2021	$32.4	$23.1	$55.5
2022	$18.7	$9.4	$28.1
2023	$9.4	$9.4	$18.7
2024	$0.0	$0.0	$0.0
Total	$584.9	$443.1	$1,028.0
NPV 2004-2036	$408.7	$308.0	$716.7

We have assumed that all equipment fixed costs (redesign and product literature) occur over a two year span preceding the first year any emission control device is introduced into the market. Where a phase-in exists (e.g., for NOx standards on >75 horsepower engines), expenditures are assumed to occur over the two year span preceding the first year NOx adsorbers would be introduced, and then to continue during the phase-in years; the expenditures would be incurred in a manner consistent with the phase-in of the standard. All expenditures are then recovered by the equipment manufacturer over 10 years following the introduction of the technology. We have assumed a seven percent rate of return for all equipment fixed costs to reflect the time value of money.

We have calculated the net present value of the equipment fixed costs over the 30 year period following implementation of the program as $720 million. This value assumes a three percent social discount rate and a 2004 date for promulgation of the final standards.

8.3.2 Aggregate Equipment Variable Costs

The equipment variable costs including sheet metal costs, mounting hardware, labor, etc. were estimated by horsepower category in Section 6.3. The variable costs were aggregated by multiplying the cost per unit within each horsepower category by the projected sales of that horsepower category. The aggregate equipment variable costs through 2036 are presented in Table 8.3-2. Table 8.3-3 shows the total aggregate equipment variable costs allocated by pollutant (refer to Table 8.1-2 for how costs have been allocated to PM and NOx).

Table 8.3-2
Aggregate Equipment Variable Costs by Horsepower Category (millions)

Year	0<hp<25	25≤hp<50	50≤hp<75	75≤hp<100	100≤hp<175	175≤hp<300	300≤hp<600	600≤hp≤750	>750hp	Total
2004	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2005	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2006	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2007	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2008	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2009	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2010	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
2011	$0.0	$0.0	$0.0	$0.0	$0.0	$5.4	$5.2	$0.5	$0.4	$11.5
2012	$0.0	$0.0	$0.0	$4.8	$7.8	$5.5	$5.3	$0.5	$0.4	$24.2
2013	$0.0	$3.2	$2.1	$4.8	$7.9	$5.6	$5.4	$0.5	$0.4	$29.9
2014	$0.0	$3.2	$2.2	$4.9	$8.0	$5.7	$5.4	$0.5	$0.8	$30.8
2015	$0.0	$3.3	$2.2	$5.0	$8.2	$5.8	$5.5	$0.5	$0.8	$31.2
2016	$0.0	$3.4	$2.3	$5.1	$8.3	$5.9	$5.5	$0.5	$0.8	$31.7
2017	$0.0	$3.4	$2.3	$5.2	$8.4	$6.0	$5.6	$0.5	$0.8	$32.2
2018	$0.0	$3.5	$2.3	$5.2	$8.6	$6.1	$5.7	$0.5	$0.8	$32.7
2019	$0.0	$3.6	$2.4	$5.3	$8.7	$6.2	$5.7	$0.5	$0.8	$33.2
2020	$0.0	$3.6	$2.4	$5.4	$8.8	$6.3	$5.8	$0.5	$0.8	$33.7
2021	$0.0	$3.7	$2.4	$5.5	$8.9	$6.4	$5.8	$0.5	$0.9	$34.1
2022	$0.0	$3.7	$2.5	$5.6	$9.1	$6.5	$5.9	$0.5	$0.9	$34.6
2023	$0.0	$3.8	$2.5	$5.7	$9.2	$6.6	$6.0	$0.5	$0.9	$35.1
2024	$0.0	$3.9	$2.5	$5.7	$9.3	$6.7	$6.0	$0.6	$0.9	$35.6
2025	$0.0	$3.9	$2.6	$5.8	$9.5	$6.8	$6.1	$0.6	$0.9	$36.1
2026	$0.0	$4.0	$2.6	$5.9	$9.6	$6.9	$6.1	$0.6	$0.9	$36.6
2027	$0.0	$4.1	$2.7	$6.0	$9.7	$7.0	$6.2	$0.6	$0.9	$37.1
2028	$0.0	$4.1	$2.7	$6.1	$9.8	$7.1	$6.2	$0.6	$0.9	$37.5
2029	$0.0	$4.2	$2.7	$6.1	$10.0	$7.2	$6.3	$0.6	$0.9	$38.0
2030	$0.0	$4.2	$2.8	$6.2	$10.1	$7.3	$6.4	$0.6	$1.0	$38.5
2031	$0.0	$4.3	$2.8	$6.3	$10.2	$7.4	$6.4	$0.6	$1.0	$39.0
2032	$0.0	$4.4	$2.8	$6.4	$10.4	$7.5	$6.5	$0.6	$1.0	$39.5
2033	$0.0	$4.4	$2.9	$6.5	$10.5	$7.6	$6.5	$0.6	$1.0	$40.0
2034	$0.0	$4.5	$2.9	$6.6	$10.6	$7.7	$6.6	$0.6	$1.0	$40.5
2035	$0.0	$4.6	$2.9	$6.6	$10.7	$7.8	$6.7	$0.6	$1.0	$40.9
2036	$0.0	$4.6	$3.0	$6.7	$10.9	$7.9	$6.7	$0.6	$1.0	$41.4
NPV 2004-2036	$0.0	$50.9	$33.6	$79.5	$129.3	$96.8	$88.1	$8.0	$12.1	$498.3

Table 8.3-3
Aggregate Equipment Variable Costs by Pollutant (millions)

Year	PM Costs	NOx+NMHC Costs	Total
2008	$0.0	$0.0	$0.0
2009	$0.0	$0.0	$0.0
2010	$0.0	$0.0	$0.0
2011	$5.7	$5.7	$11.5
2012	$12.1	$12.1	$24.2
2013	$17.6	$12.3	$29.9
2014	$18.1	$12.7	$30.8
2015	$18.4	$12.9	$31.2
2016	$18.7	$13.1	$31.7
2017	$19.0	$13.2	$32.2
2018	$19.3	$13.4	$32.7
2019	$19.5	$13.6	$33.2
2020	$19.8	$13.8	$33.7
2021	$20.1	$14.0	$34.1
2022	$20.4	$14.2	$34.6
2023	$20.7	$14.4	$35.1
2024	$21.0	$14.6	$35.6
2025	$21.3	$14.8	$36.1
2026	$21.6	$15.0	$36.6
2027	$21.9	$15.2	$37.1
2028	$22.2	$15.4	$37.5
2029	$22.5	$15.6	$38.0
2030	$22.8	$15.8	$38.5
2031	$23.1	$16.0	$39.0
2032	$23.3	$16.1	$39.5
2033	$23.6	$16.3	$40.0
2034	$23.9	$16.5	$40.5
2035	$24.2	$16.7	$40.9
2036	$24.5	$16.9	$41.4
NPV 2004-2036	$291.4	$206.9	$498.3

8.4 Aggregate Fuel Costs and Other Operating Costs

Aggregate costs presented here are used in the calculation of costs per ton of emissions that would be reduced by the proposed standards for nonroad fuel and engines. We are proposing a 500 ppm sulfur cap on nonroad, locomotive, and marine fuels beginning in 2007. In Section 8.4.2 we summarize the costs for this program as if it remained in place for 30 years, even though it would be supplanted by the second step of our fuel program in 2010.

We are also proposing a second step in the fuel program that would cap nonroad fuel sulfur levels at 15 ppm beginning in 2010. This fuel program enables the introduction of advanced emission control technologies including CDPFs and NOx adsorbers. The combination of the two-step fuel program and the new diesel engine standards represents the total Tier 4 program for nonroad diesel engines and fuel proposed today. In Section 8.4.1 we present our estimate of the annual and total costs for this complete program beginning in 2007 and continuing for 30 years.

8.4.1 Aggregate Fuel Costs

Fuel costs are developed on a cents per gallon basis. Chapter 7 contains a description of the development of fuel costs for the proposed fuel program. Table 8.4-1 contains a summary of cent/gallon fuel costs, estimated fuel volumes for nonroad, locomotive, and marine, and the aggregate fuel costs through 2036 for the proposed two-step fuel program. Table 8.4-2 shows the same information assuming the proposed 500 ppm fuel program remained in place indefinitely and no new engine standards were implemented.

Table 8.4-1
Aggregate Fuel Costs of the Proposed Two-Step Fuel Program (millions)

Year	Aggregate Fuel Costs of Proposed Two-Step Fuel Program							
	Affected Volume for 500 ppm (gallons)*			Affected Volume for 15 ppm (gallons)*		Aggregate Fuel Costs		
	2007-2010 at $/gal cost of $0.025	2010-2014 at $/gal cost of $0.026	2014+ at $/gal cost of $0.024	2010-2014 at $/gal cost of $0.048	2014+ at $/gal cost of $0.048	500 ppm	15 ppm	Total
2004	0	0	0	0	0	$0	$0	$0
2005	0	0	0	0	0	$0	$0	$0
2006	0	0	0	0	0	$0	$0	$0
2007	5,449	0	0	0	0	$136	$0	$136
2008	9,504	0	0	0	0	$238	$0	$238
2009	9,671	0	0	0	0	$242	$0	$242
2010	4,099	2,892	0	3,495	0	$178	$168	$345
2011	0	5,034	0	6,124	0	$131	$294	$425
2012	0	5,088	0	6,256	0	$132	$300	$433
2013	0	5,137	0	6,389	0	$134	$307	$440
2014	0	2,162	2,369	2,717	4,461	$113	$345	$458
2015	0	0	4,093	0	7,803	$98	$375	$473
2016	0	0	4,136	0	7,957	$99	$382	$481
2017	0	0	4,170	0	8,111	$100	$389	$489
2018	0	0	4,203	0	8,265	$101	$397	$498
2019	0	0	4,238	0	8,419	$102	$404	$506
2020	0	0	4,268	0	8,573	$102	$412	$514
2021	0	0	4,311	0	8,727	$103	$419	$522
2022	0	0	4,354	0	8,881	$104	$426	$531
2023	0	0	4,397	0	9,035	$106	$434	$539
2024	0	0	4,441	0	9,190	$107	$441	$548
2025	0	0	4,485	0	9,344	$108	$448	$556
2026	0	0	4,530	0	9,497	$109	$456	$565
2027	0	0	4,575	0	9,650	$110	$463	$573
2028	0	0	4,621	0	9,803	$111	$471	$581
2029	0	0	4,668	0	9,956	$112	$478	$590
2030	0	0	4,715	0	10,110	$113	$485	$598
2031	0	0	4,763	0	10,263	$114	$493	$607
2032	0	0	4,811	0	10,416	$115	$500	$615
2033	0	0	4,859	0	10,569	$117	$507	$624
2034	0	0	4,908	0	10,723	$118	$515	$632
2035	0	0	4,958	0	10,876	$119	$522	$641
2036	0	0	5,008	0	11,029	$120	$529	$650
NPV 2004-2036	25,206	16,077	54,791	19,763	112,851	$2,363	$6,366	$8,729

* Note that “Affected Volumes” for 500 ppm and 15 ppm are taken from Table 7.1-35.

Table 8.4-2
Aggregate Fuel Costs for the 500 ppm Fuel Program (millions)

Year	Aggregate Fuel Costs of 500 ppm Fuel Program		
	Affected Volume for 500 ppm (gallons)*		Aggregate Fuel Costs
	2007-2010 at $/gal cost of $0.025	2010+ at $/gal cost of $0.024	Total
2004	0	0	$0
2005	0	0	$0
2006	0	0	$0
2007	5,449	0	$136
2008	9,504	0	$238
2009	9,671	0	$242
2010	4,099	6,387	$256
2011	0	11,158	$268
2012	0	11,344	$272
2013	0	11,526	$277
2014	0	11,709	$281
2015	0	11,895	$285
2016	0	12,092	$290
2017	0	12,281	$295
2018	0	12,468	$299
2019	0	12,657	$304
2020	0	12,841	$308
2021	0	13,038	$313
2022	0	13,235	$318
2023	0	13,432	$322
2024	0	13,630	$327
2025	0	13,829	$332
2026	0	14,027	$337
2027	0	14,226	$341
2028	0	14,425	$346
2029	0	14,624	$351
2030	0	14,825	$356
2031	0	15,025	$361
2032	0	15,227	$365
2033	0	15,429	$370
2034	0	15,631	$375
2035	0	15,834	$380
2036	0	16,037	$385
NPV 2004-2036	25,206	203,483	$5,514

* Note that the 2010+ gallons shown here are the summation of the 2010-2014 and 2014+ columns for both 500 ppm and 15 ppm fuel shown in Table 8.4-1 because there would be no introduction of 15 ppm fuel under the 500 ppm fuel program.

8.4.2 Aggregate Oil Change Maintenance Savings

Maintenance savings associated with extended oil change intervals are developed on a cents per gallon basis. Section 6.2.3 contains a description of the development of maintenance savings for the proposed program. Table 8.4-3 contains a summary of the maintenance savings and

estimated fuel volumes for nonroad, locomotive, and marine through 2036 for the proposed two-step fuel program. Also presented in Table 8.4-3 are the maintenance savings of the 500 ppm fuel program assuming it remained in place indefinitely and no new engine standards were implemented. Note that the nonroad volumes shown in Table 8.4-3 under the 500 ppm fuel program are the summation of the two columns of nonroad volumes shown under the proposed fuel program (500 ppm during 2007 through part of 2010 and 15 ppm for the remainder of 2010 and beyond). The cent per gallon savings for locomotive and marine shown in Table 8.4-3 are taken from Table 6.2-26 (see also Table 6.4-3) while the cent per gallon savings shown for nonroad are taken from the discussion in section 6.2.3.1 (these values can also be derived using data shown in Table 6.2-26 by weighting the cent per gallon savings within each horsepower range by the fuel use weighting for that horsepower range – the summation of these weighted values for all horsepower ranges is 3.3 cents per gallon for 15 ppm fuel and 3.0 cents per gallon for 500 ppm fuel).

Table 8.4-3

Oil Change Maintenance Savings Associated with the Proposed Two-Step and the 500 ppm Fuel Programs (millions)

	Aggregate Maintenance Savings of Proposed Fuel Program						Aggregate Maintenance Savings of 500 ppm Fuel Program		
	500 ppm Volumes		15 ppm Volume	Aggregate Maintenance Savings			500 ppm Volume		Aggregate Maintenance Savings
Year	Nonroad Volume* at $/gal savings of $0.030	Loco&Marine Volume* at $/gal savings of $0.011	Nonroad Volume* at $/gal savings of $0.033	500 ppm	15 ppm	Total	Nonroad Volume* at $/gal savings of $0.030	Loco&Marine Volume* at $/gal savings of $0.011	Total
2004	0	0	0	$0	$0	$0	0	0	$0
2005	0	0	0	$0	$0	$0	0	0	$0
2006	0	0	0	$0	$0	$0	0	0	$0
2007	3,298	1,780	0	-$118	$0	-$118	3,298	1,780	-$118
2008	5,788	3,073	0	-$206	$0	-$206	5,788	3,073	-$206
2009	5,923	3,100	0	-$210	$0	-$210	5,923	3,100	-$210
2010	2,524	3,127	3,533	-$110	-$115	-$225	6,057	3,127	-$215
2011	0	3,416	6,025	-$38	-$196	-$234	6,025	3,416	-$217
2012	0	3,441	6,156	-$38	-$200	-$239	6,156	3,441	-$221
2013	0	3,462	6,288	-$39	-$205	-$243	6,288	3,462	-$225
2014	0	3,484	6,419	-$39	-$209	-$248	6,419	3,484	-$229
2015	0	3,484	7,545	-$39	-$246	-$284	7,545	3,484	-$263
2016	0	3,510	7,700	-$39	-$251	-$290	7,700	3,510	-$268
2017	0	3,548	7,853	-$40	-$256	-$295	7,853	3,548	-$273
2018	0	3,576	8,006	-$40	-$261	-$300	8,006	3,576	-$278
2019	0	3,604	8,159	-$40	-$266	-$306	8,159	3,604	-$283
2020	0	3,634	8,312	-$40	-$270	-$311	8,312	3,634	-$287
2021	0	3,658	8,465	-$41	-$275	-$316	8,465	3,658	-$292
2022	0	3,695	8,619	-$41	-$280	-$322	8,619	3,695	-$297
2023	0	3,732	8,772	-$42	-$285	-$327	8,772	3,732	-$302
2024	0	3,770	8,925	-$42	-$290	-$332	8,925	3,770	-$307
2025	0	3,808	9,078	-$42	-$295	-$338	9,078	3,808	-$312
2026	0	3,846	9,231	-$43	-$300	-$343	9,231	3,846	-$317
2027	0	3,885	9,383	-$43	-$305	-$349	9,383	3,885	-$322
2028	0	3,924	9,535	-$44	-$310	-$354	9,535	3,924	-$327
2029	0	3,964	9,687	-$44	-$315	-$359	9,687	3,964	-$332
2030	0	4,005	9,839	-$45	-$320	-$365	9,839	4,005	-$337
2031	0	4,046	9,992	-$45	-$325	-$370	9,992	4,046	-$342
2032	0	4,087	10,144	-$46	-$330	-$376	10,144	4,087	-$347
2033	0	4,129	10,296	-$46	-$335	-$381	10,296	4,129	-$352
2034	0	4,171	10,448	-$46	-$340	-$386	10,448	4,171	-$357
2035	0	4,214	10,600	-$47	-$345	-$392	10,600	4,214	-$362
2036	0	4,257	10,752	-$47	-$350	-$397	10,752	4,257	-$367
NPV 2004-2036	**15,383**	**65,449**	**128,702**	**-$1,186**	**-$4,188**	**-$5,374**	**144,086**	**65,449**	**-$5,009**

* Note that volumes are taken from Table 7.1-34 and are expressed in millions of gallons (volumes here do not include highway spillover volumes). Factors of 5/12 (Jan through May) and 7/12 (Jun through Dec) have been used in this table during transition years.

8.4.3 Aggregate CDPF & CCV Maintenance Costs and CDPF Regeneration Costs

Maintenance costs associated with CDPF maintenance and CCV maintenance are developed on a cents per gallon basis. Section 6.2.3 contains a description of the development of maintenance costs for the proposed program. Table 8.4-4 contains a summary of the maintenance costs and estimated fuel volumes for CDPF and CCV equipped engines through 2036 for the proposed two-step fuel program. Note that there are no maintenance costs or CDPF regeneration costs associated with the 500 ppm fuel program because that program has no new engine standards and, therefore, neither CDPF nor CCV hardware would be added to new engines. The fuel volumes shown in Table 8.4-4 differ from those shown in Tables 8.4-1 through 8.4-3 because the volumes of importance for maintenance costs are not volumes consumed by nonroad engines but rather volumes consumed by CDPF and CCV equipped engines (i.e., new engines that comply with the proposed standards). The CDPF volumes shown in Table 8.4-4 contain some highway spillover volumes so they do not match the nonroad volumes of Tables 8.4-1 through Table 8.4-3 even in the later years. The volumes shown for <75 horsepower engines are used only for CCV maintenance costs during the years from 2008 through 2012 after which time their volumes are captured by the CDPF volumes shown in the Table.

The cent per gallon costs shown for CDPF maintenance are taken from Table 6.2-27. The value can be derived using data shown in Table 6.2-26 by weighting the cent per gallon savings within each horsepower range by the fuel use weighting for that horsepower range – the summation of these weighted values for all horsepower ranges is 0.6 cents per gallon; note that weighting these values to reflect the phase-in schedule is not necessary since the volume of fuel already reflects this weighting. The cent per gallon costs shown for CCV maintenance are taken from Table 6.2-28, again doing a weighting for each horsepower range using the fuel use weightings shown in Table 6.2-28 (note that these fuel use weightings include the turbo-charged fraction shown in Table 6.2-28 because only turbo-charged engines would be adding the CCV system). Because the volumes shown for <75 horsepower engines includes volumes burned by non-turbo charged engines, it is necessary to weight the cent per gallon value by the phase-in schedule of the proposed standards; as a result, this value does not remain constant until 2013 and beyond. The cent per gallon costs shown for CDPF regeneration are taken from Table 6.4-3. Because of the phase-in schedule of the standards and the different fuel economy impacts of engines equipped with both a CDPF and a NOx adsorber (1 percent) versus a CDPF-only (2%), this value varies during the phase-in years before leveling off at a fleetwide average of 0.77 cents per gallon.

Table 8.4-4
CDPF & CCV Maintenance Costs and CDPF Regeneration Costs Associated with the Proposed Two-Step Fuel Program (millions)

						Aggregate Maintenance Costs of Proposed Fuel Program			
Year	Fuel Volume in CDPF engines*	Fuel Volume in <75hp engines during 2008-2012*	CDPF Maintenance CDPF-fleet weighted $/gal cost	CDPF Regeneration CDPF-fleet weighted $/gal cost**	CCV Maintenance CCV-fleet weighted $/gal cost	CDPF Maintenance	CDPF Regeneration	CCV Maintenance	Total
2004	0	0				$0	$0	$0	$0
2005	0	0				$0	$0	$0	$0
2006	0	0				$0	$0	$0	$0
2007	0	0				$0	$0	$0	$0
2008	0	163			$0.0004	$0	$0	$0	$0
2009	0	316			$0.0004	$0	$0	$0	$0
2010	0	477			$0.0004	$0	$0	$0	$0
2011	450	644	$0.0060	$0.0047	$0.0012	$3	$2	$1	$6
2012	1,310	818	$0.0060	$0.0073	$0.0017	$8	$10	$4	$21
2013	2,255	0	$0.0060	$0.0099	$0.0017	$13	$22	$4	$39
2014	3,249	0	$0.0060	$0.0077	$0.0017	$19	$25	$6	$50
2015	4,230	0	$0.0060	$0.0077	$0.0017	$25	$33	$7	$65
2016	5,172	0	$0.0060	$0.0077	$0.0017	$31	$40	$9	$80
2017	6,064	0	$0.0060	$0.0077	$0.0017	$36	$47	$11	$94
2018	6,880	0	$0.0060	$0.0077	$0.0017	$41	$53	$12	$106
2019	7,628	0	$0.0060	$0.0077	$0.0017	$46	$59	$13	$118
2020	8,314	0	$0.0060	$0.0077	$0.0017	$50	$64	$14	$129
2021	8,936	0	$0.0060	$0.0077	$0.0017	$53	$69	$16	$138
2022	9,511	0	$0.0060	$0.0077	$0.0017	$57	$74	$17	$147
2023	10,041	0	$0.0060	$0.0077	$0.0017	$60	$78	$17	$155
2024	10,540	0	$0.0060	$0.0077	$0.0017	$63	$82	$18	$163
2025	11,011	0	$0.0060	$0.0077	$0.0017	$66	$85	$19	$170
2026	11,445	0	$0.0060	$0.0077	$0.0017	$68	$89	$20	$177
2027	11,834	0	$0.0060	$0.0077	$0.0017	$71	$92	$21	$183
2028	12,183	0	$0.0060	$0.0077	$0.0017	$73	$94	$21	$188
2029	12,516	0	$0.0060	$0.0077	$0.0017	$75	$97	$22	$194
2030	12,836	0	$0.0060	$0.0077	$0.0017	$77	$99	$22	$198
2031	13,165	0	$0.0060	$0.0077	$0.0017	$79	$102	$23	$204
2032	13,502	0	$0.0060	$0.0077	$0.0017	$81	$105	$23	$209
2033	13,848	0	$0.0060	$0.0077	$0.0017	$83	$107	$24	$214
2034	14,203	0	$0.0060	$0.0077	$0.0017	$85	$110	$25	$220
2035	14,567	0	$0.0060	$0.0077	$0.0017	$87	$113	$25	$225
2036	14,940	0	$0.0060	$0.0077	$0.0017	$89	$116	$26	$231
NPV 2004-2036	**124,535**	**1,986**				**$745**	**$966**	**$218**	**$1,929**

*Note that fuel used in CDPF engines includes some highway spillover fuel. Refer to Table 7.1-34 for totoal nonroad volumes including highway spillover volumes; CDPF volumes are less than that total volume even in 2036 (14,940 vs. 15,626 million gallons) because some pre-control engines would still remain in the fleet. Note that fuel volumes in <75hp engines are used for CCV maintenance costs from 2008 to 2012, after which time their volumes are captured in the CDPF volumes.

**CDPF Regeneration $/gal costs change due to different fuel economy impacts with a NOx adsorber (1%) and without a NOx adsorber (2%) matched with the phase-in schedules of the proposed standards.

8.4.4 Summary of Aggregate Operating Costs

The net operating costs include the incremental costs for fuel (Table 8.4-1), costs for oil change maintenance savings (Table 8.4-3 for the proposed fuel program), and costs for CDPF maintenance, CCV maintenance, and CDPF regeneration (Table 8.4-4). The results of this summation for the proposed two-step fuel program are shown in Table 8.4-5. The oil change maintenance savings, CDPF and CCV maintenance costs, and CDPF regeneration costs are added together in Table 8.4-5 and presented as "Net Maintenance Costs." The net maintenance costs are presented as negative values, thus, they represent a net savings. The "Net Operating Cost" is the sum of the incremental fuel costs (both the 500 ppm fuel for nonroad, locomotive, and marine from 2007 through 2010, 500 ppm fuel for locomotive and marine in 2010 and beyond, and 15 ppm fuel for nonroad in 2010 and beyond) and the net maintenance costs. Table 8.4-5 also presents the allocation of these costs to each pollutant (refer to Table 8.1-2 for how these costs have been allocated). The sum of the SOx cost, the PM cost, and the NOx+NMHC cost is the value presented in the "Net Operating Cost" column. As shown in the table, the net present value during the period 2004 through 2036 of the proposed two-step fuel program is $5.3 billion using a three percent social discount rate, consisting of $8.7 billion in incremental fuel costs and $3.4 billion in net maintenance savings.

Table 8.4-6 presents the net operating costs associated with the 500 ppm fuel program. The costs presented in Table 8.4-6 include the incremental costs for fuel (Table 8.4-2), and costs for oil change maintenance savings (Table 8.4-3 for the 500 ppm fuel program). The oil change maintenance savings are presented in the table as "Net Maintenance Costs," and, thus, represent a net savings. The "Net Operating Cost" is the sum of the incremental fuel costs and the net maintenance costs. Table 8.4-6 also presents the allocation of these costs to each pollutant (refer to Table 8.1-2 for how these costs have been allocated). The costs shown in Table 8.4-6 assume the 500 ppm fuel program remains in place indefinitely. As a result, no new NOx and/or PM standards would be implemented. The 500 ppm fuel would result in large SOx reductions and, by comparison, smaller but still important PM reductions. Since the largest reduction is in SOx emissions, we have simply attributed all costs for the 500 ppm fuel program to SOx for our cost per ton calculations. Note that our emissions inventory projections and our benefits analysis include these PM reductions. We have also presented the SOx costs with maintenance savings (i.e., the net total cost) and without maintenance savings (i.e., the incremental fuel cost) so that a cost per ton can be calculated with and without the maintenance savings.

Table 8.4-5

Aggregate Net Operating Costs Associated with the Proposed Two-Step Fuel Program (millions)

	Aggregate Net Operating Costs of the Proposed Two-Step Fuel Program							
Year	500 ppm Fuel Costs	15 ppm Fuel Costs	Total Fuel Costs	Net Maintenance Costs	Net Operating Cost	SOx Cost	PM Cost	NOx+NMHC Cost
2004	$0	$0	$0	$0	$0	$0	$0	$0
2005	$0	$0	$0	$0	$0	$0	$0	$0
2006	$0	$0	$0	$0	$0	$0	$0	$0
2007	$136	$0	$136	-$118	$18	$18	$0	$0
2008	$238	$0	$238	-$206	$32	$31	$0	$0
2009	$242	$0	$242	-$210	$31	$31	$0	$0
2010	$178	$168	$345	-$225	$121	$68	$26	$26
2011	$131	$294	$425	-$228	$197	$93	$54	$50
2012	$132	$300	$433	-$218	$215	$94	$69	$52
2013	$134	$307	$440	-$204	$236	$95	$89	$53
2014	$113	$345	$458	-$197	$260	$74	$115	$71
2015	$98	$375	$473	-$219	$254	$59	$126	$68
2016	$99	$382	$481	-$210	$271	$60	$141	$70
2017	$100	$389	$489	-$201	$288	$61	$155	$72
2018	$101	$397	$498	-$194	$304	$61	$168	$74
2019	$102	$404	$506	-$188	$318	$62	$181	$76
2020	$102	$412	$514	-$182	$332	$62	$192	$78
2021	$103	$419	$522	-$178	$344	$63	$202	$79
2022	$104	$426	$531	-$175	$356	$63	$212	$81
2023	$106	$434	$539	-$172	$367	$64	$221	$83
2024	$107	$441	$548	-$169	$378	$65	$229	$85
2025	$108	$448	$556	-$168	$389	$65	$237	$86
2026	$109	$456	$565	-$166	$398	$66	$245	$88
2027	$110	$463	$573	-$166	$407	$67	$252	$89
2028	$111	$471	$581	-$166	$416	$67	$258	$91
2029	$112	$478	$590	-$166	$424	$68	$264	$92
2030	$113	$485	$598	-$166	$432	$69	$270	$94
2031	$114	$493	$607	-$167	$440	$69	$276	$95
2032	$115	$500	$615	-$167	$449	$70	$282	$97
2033	$117	$507	$624	-$167	$457	$71	$288	$98
2034	$118	$515	$632	-$167	$466	$71	$295	$100
2035	$119	$522	$641	-$167	$474	$72	$301	$101
2036	$120	$529	$650	-$166	$483	$73	$308	$103
NPV 2004-2036	**$2,363**	**$6,366**	**$8,729**	**-$3,445**	**$5,284**	**$1,177**	**$2,909**	**$1,198**

Note: for fuel costs see Table 8.4-1; for maintenance costs see Tables 8.4-3 and 8.4-4; for cost allocations by pollutant see Table 8.1-2.

Table 8.4-6
Aggregate Net Operating Costs Associated with the 500 ppm Fuel Program (millions)

	Aggregate Net Operating Costs of 500 ppm Fuel Program				
Year	Total Fuel Costs	Net Maintenance Costs	Net Operating Cost	SOx Cost w/ Maintenance Savings	SOx Cost w/o Maintenance Savings
2004	$0	$0	$0	$0	$0
2005	$0	$0	$0	$0	$0
2006	$0	$0	$0	$0	$0
2007	$136	-$118	$18	$18	$136
2008	$238	-$206	$31	$31	$238
2009	$242	-$210	$31	$31	$242
2010	$256	-$215	$41	$41	$256
2011	$268	-$217	$51	$51	$268
2012	$272	-$221	$51	$51	$272
2013	$277	-$225	$51	$51	$277
2014	$281	-$229	$52	$52	$281
2015	$285	-$263	$23	$23	$285
2016	$290	-$268	$22	$22	$290
2017	$295	-$273	$22	$22	$295
2018	$299	-$278	$22	$22	$299
2019	$304	-$283	$21	$21	$304
2020	$308	-$287	$21	$21	$308
2021	$313	-$292	$21	$21	$313
2022	$318	-$297	$20	$20	$318
2023	$322	-$302	$20	$20	$322
2024	$327	-$307	$20	$20	$327
2025	$332	-$312	$20	$20	$332
2026	$337	-$317	$20	$20	$337
2027	$341	-$322	$19	$19	$341
2028	$346	-$327	$19	$19	$346
2029	$351	-$332	$19	$19	$351
2030	$356	-$337	$19	$19	$356
2031	$361	-$342	$19	$19	$361
2032	$365	-$347	$19	$19	$365
2033	$370	-$352	$18	$18	$370
2034	$375	-$357	$18	$18	$375
2035	$380	-$362	$18	$18	$380
2036	$385	-$367	$18	$18	$385
NPV 2004-2036	**$5,514**	**-$5,009**	**$505**	**$505**	**$5,514**

Note: for fuel costs see Table 8.4-2; for cost allocations by pollutant see Table 8.1-2.

8.5 Summary of Total Aggregate Costs of the Proposed Program

Table 8.5-1 presents a summary of all the costs presented above for the proposed program. Engine costs are the summation of costs presented in Tables 8.2-1 and 8.2-2, equipment costs are the summation of costs presented in Tables 8.3-1 and 8.3-2, and fuel costs and net maintenance costs are presented in Table 8.4-5. The "Total Program Costs" are the summation of engine costs, equipment costs, and net fuel costs. Table 8.5-2 presents the summary of all the costs

presented above for the proposed program by pollutant (refer to Table 8.1-2 for how we have allocated costs among the various pollutants). We did the cost analysis using a 3% discount rate. We will also be conducting a similar analysis using a 7% discount rate and including this information in the docket.

Note that the total aggregate costs associated with the 500 ppm fuel program are presented in full in Table 8.4-6 since there are no new engine or equipment costs associated with that program.

Table 8.5-1
Summary of Aggregate Costs for the Proposed Two-Step Fuel and Engine Program by Segment
(millions)

Year	Engine Costs	Equipment Costs	Fuel Costs	Net Maintenance Costs	Net Operating Costs	Total Costs
2004	$0	$0	$0	$0	$0	$0
2005	$0	$0	$0	$0	$0	$0
2006	$0	$0	$0	$0	$0	$0
2007	$0	$0	$136	-$118	$18	$18
2008	$80	$5	$238	-$206	$32	$117
2009	$82	$5	$242	-$210	$31	$118
2010	$79	$5	$345	-$225	$121	$205
2011	$410	$59	$425	-$228	$197	$665
2012	$723	$99	$433	-$218	$215	$1,037
2013	$875	$114	$440	-$204	$236	$1,226
2014	$973	$134	$458	-$197	$260	$1,367
2015	$889	$134	$473	-$219	$254	$1,277
2016	$909	$135	$481	-$210	$271	$1,315
2017	$912	$135	$489	-$201	$288	$1,335
2018	$908	$131	$498	-$194	$304	$1,342
2019	$907	$131	$506	-$188	$318	$1,356
2020	$921	$132	$514	-$182	$332	$1,384
2021	$934	$90	$522	-$178	$344	$1,368
2022	$948	$63	$531	-$175	$356	$1,367
2023	$962	$54	$539	-$172	$367	$1,383
2024	$975	$36	$548	-$169	$378	$1,389
2025	$989	$36	$556	-$168	$389	$1,414
2026	$1,003	$37	$565	-$166	$398	$1,438
2027	$1,016	$37	$573	-$166	$407	$1,461
2028	$1,030	$38	$581	-$166	$416	$1,484
2029	$1,044	$38	$590	-$166	$424	$1,506
2030	$1,058	$39	$598	-$166	$432	$1,528
2031	$1,071	$39	$607	-$167	$440	$1,550
2032	$1,085	$39	$615	-$167	$449	$1,573
2033	$1,099	$40	$624	-$167	$457	$1,596
2034	$1,112	$40	$632	-$167	$466	$1,618
2035	$1,126	$41	$641	-$167	$474	$1,641
2036	$1,140	$41	$650	-$166	$483	$1,664
NPV 2004-2036	$14,215	$1,215	$8,729	($3,445)	$5,284	$20,713

Table 8.5-2
Summary of Aggregate Costs for the Proposed Two-Step Fuel and Engine Program by Pollutant
(millions)

Year	PM Costs	NOx+NMHC Costs	SOx Costs	Total Costs
2004	$0	$0	$0	$0
2005	$0	$0	$0	$0
2006	$0	$0	$0	$0
2007	$0	$0	$18	$18
2008	$85	$0	$31	$117
2009	$86	$0	$31	$118
2010	$111	$27	$68	$205
2011	$400	$172	$93	$665
2012	$664	$279	$94	$1,037
2013	$826	$304	$95	$1,226
2014	$829	$463	$74	$1,367
2015	$761	$457	$59	$1,277
2016	$806	$449	$60	$1,315
2017	$825	$450	$61	$1,335
2018	$825	$456	$61	$1,342
2019	$846	$448	$62	$1,356
2020	$867	$455	$62	$1,384
2021	$865	$440	$63	$1,368
2022	$871	$433	$63	$1,367
2023	$880	$440	$64	$1,383
2024	$888	$437	$65	$1,389
2025	$906	$443	$65	$1,414
2026	$922	$449	$66	$1,438
2027	$939	$456	$67	$1,461
2028	$954	$462	$67	$1,484
2029	$970	$468	$68	$1,506
2030	$985	$475	$69	$1,528
2031	$1,000	$481	$69	$1,550
2032	$1,016	$487	$70	$1,573
2033	$1,032	$493	$71	$1,596
2034	$1,047	$500	$71	$1,618
2035	$1,063	$506	$72	$1,641
2036	$1,079	$512	$73	$1,664
NPV 2004-2036	$13,117	$6,419	$1,177	$20,713

8.6 Emission Reductions

Table 8.6-1 presents the emission reductions estimated to result from the proposed two-step fuel program in conjunction with the proposed engine program. Also presented are reductions associated with the 500 ppm fuel program. A complete discussion of these emission reductions and how they were generated can be found in Chapter 3 of this draft RIA.

Table 8.6-1
Emission Reductions Associated with the Proposed Two-Step Fuel and Engine Program (tons)[a]

Year	Proposed Two-Step Fuel Program and Engine Program			500 ppm Fuel Program
	NOx+NMHC	PM	SOx	SOx[b]
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	11,636	144,298	144,298
2008	331	20,911	252,100	252,100
2009	679	21,936	256,935	256,935
2010	1,100	23,976	273,470	261,786
2011	21,527	27,947	287,583	267,117
2012	54,771	34,221	292,817	271,879
2013	92,356	41,592	297,975	276,559
2014	159,869	49,424	303,138	281,244
2015	227,196	57,447	308,386	286,014
2016	293,259	65,327	313,862	291,018
2017	356,969	72,981	319,130	295,815
2018	416,003	80,207	324,374	300,591
2019	471,893	86,972	329,641	305,392
2020	523,758	93,290	334,799	310,086
2021	569,840	99,189	340,233	315,058
2022	611,898	104,709	345,674	320,039
2023	651,009	109,897	351,122	325,028
2024	687,113	114,844	356,578	330,025
2025	721,134	119,594	362,041	335,032
2026	752,239	124,061	367,483	340,021
2027	780,753	128,162	372,933	345,019
2028	807,161	131,868	378,391	350,027
2029	831,947	135,400	383,859	355,045
2030	854,392	138,813	389,337	360,073
2031	875,480	141,991	394,825	365,112
2032	895,923	145,065	400,323	370,162
2033	915,611	148,083	405,832	375,223
2034	934,719	151,025	411,352	380,295
2035	953,145	153,851	416,883	385,378
2036	971,043	156,591	422,425	390,472
NPV 2004-2036	7,909,477	1,501,011	5,977,653	5,585,742

[a] Note that values shown here are emissions reductions. Chapter 3 presents emissions inventories. The values here are the differences between the baseline inventory values and the proposal inventory values presented in Chapter 3.

[b] Note that the SOx reductions for the two-step fuel program and the 500 ppm fuel program are identical during the years 2007 through 2010 because only 500 ppm fuel is available during those years. The introduction of 15 ppm fuel in 2010 under the two-step fuel program results in slightly greater SOx reductions for that program relative to the 500 ppm fuel program.

8.7 Cost per Ton

We have calculated the cost per ton of our proposed program based on the net present value of all costs incurred and all emission reductions generated over a 30 year time window following implementation of the program. This approach captures all of the costs and emissions reductions from our proposed program including those costs incurred and emissions reductions generated by the existing fleet.

The baseline (i.e., the point of comparison) for this evaluation is the existing set of engine standards (i.e., the Tier 2/Tier 3 program) and fuel standards (i.e., unregulated sulfur level). The 30-year time window chosen is meant to capture both the early period of the program when very few new engines that meet the proposed standards would be in the fleet, and the later period when essentially all engines would meet the proposed standards. The proposed program also would require reductions in sulfur content of nonroad diesel fuel (and also locomotive and marine diesel fuel). We are proposing a 500 ppm sulfur cap on nonroad, locomotive, and marine fuels beginning in 2007. This fuel program, the first step in our two-step fuel program, provides significant air quality benefits through reduced SO_x emissions, see Tables 3.5-4 and 3.5-5, and PM emissions, see Tables 3.5-1 and 3.5-2, from both new and existing nonroad, locomotive, and marine engines. In Table 8.4-6 we summarized the cost for this program as if it remained in place for 30 years, even though it would be supplanted by the second step of our fuel program in 2010. In Table 8.6-1, we presented the SO_x emission reductions expected from this program. Here we provide an analysis of the cost per ton for the SO_x reductions that would be realized by the 500 ppm fuel program for the same 30 year time window. In this way, the cost per ton of the SO_x reductions realized by the 500 ppm fuel program can be compared to other available means to control SO_x emissions. The PM reductions are not accounted for in the relative cost per ton estimate, but are listed in Section 3.5.

We are also proposing a second step in the fuel program that would cap nonroad fuel sulfur levels at 15 ppm beginning in 2010. This fuel program enables the introduction of advanced emission control technologies including CDPFs and NOx adsorbers. The combination of the two-step fuel program and the new diesel engine standards represents the total Tier 4 program for nonroad diesel engines and fuel proposed today. In Table 8.5-2, we presented our estimate of the annual costs for this complete program by pollutant beginning in 2007 and continuing for 30 years. In Table 8.6-1, we presented the estimated emission reductions for this proposed program. Here we include an estimate of the cost per ton of emissions reductions realized by this program for NOx+NMHC, PM, and SO_x.

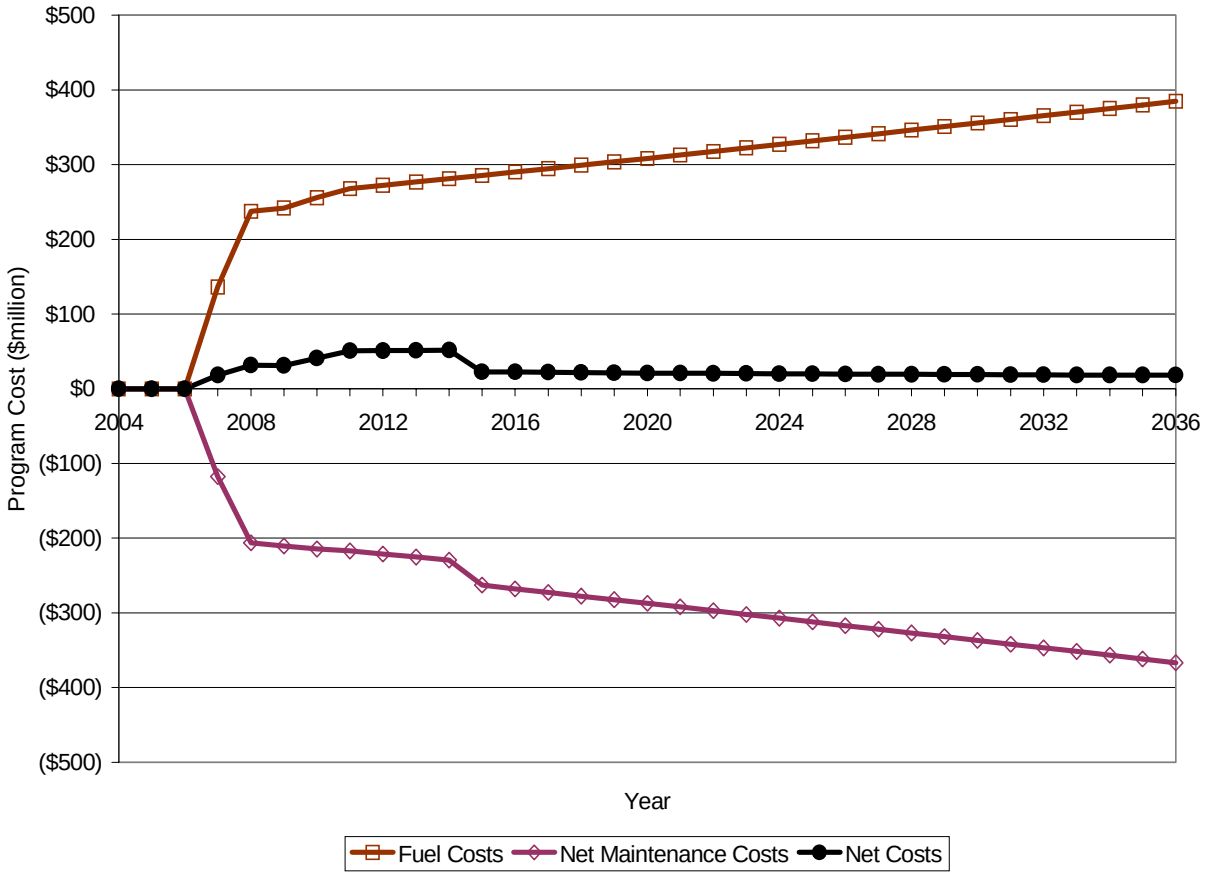
8.7.1 Cost per Ton for the 500 ppm Fuel Program

Table 8.4-6 contains the aggregate fuel costs and net maintenance costs for the 500 ppm fuel program from 2007-20036. Cost estimates in Table 8.4-6 differ from those in Table 8.5-1 (which presents total aggregate costs of the two-step fuel program plus the engine program) because the costs of the second fuel step, related engine standards, equipment modifications and associated maintenance costs are not part of the 500 ppm fuel program. Figure 8.7-1 presents the total

annual costs associated with the 500 ppm fuel program through 2036; this is a graphical representation of the data presented in Table 8.4-6

As can be seen in Figure 8.7-1, the costs for refining and distributing the 500 ppm fuel range from $250 million in 2008 to nearly $400 million in 2036. These control costs are largely offset by the maintenance savings that range from $200 million in 2008 to $380 million in 2036. As a result, the net cost of the program in each year is essentially zero, ranging from $50 million in the early years to only $18 million in 2036. The net present value of the net costs and savings associated with the proposed 500 ppm fuel program during the years 2007 to 2036 is estimated at $510 million.

Figure 8.7-1
Annual Costs of the 500 ppm Fuel Program



The 500 ppm fuel program would result in significant reductions in SO_x and PM emissions. For the existing fleet, approximately 98 percent of fuel sulfur is converted to SO_x in the engine with the remaining two percent being emitted in the exhaust as sulfate PM. Because the majority of the emissions reductions associated with this program would be SO_x, we have attributed all the

control costs to SO_x in calculating the cost per ton for the 500 ppm fuel program. Table 8.6-1 presents the SO_x reductions for the 500 ppm fuel program from 2007-2036 which are shown in the table to have a net present value of 5.6 million tons. The PM reductions for the 500 ppm fuel program are listed in Section 3.5.

Table 8.7-1 shows the cost per ton of emissions reduced as a result of the proposed 500 ppm fuel program. The cost per ton numbers include costs and emission reductions that would occur from both the new and the existing fleet (i.e., those pieces of nonroad equipment that were sold into the market prior to the proposed emission standards) of nonroad, locomotive, and marine engines. The long term cost per ton is actually negative. This occurs because nonroad engines would experience a net savings due to the 500 ppm fuel program (2.4 cents per gallon for the fuel and 3 cents per gallon for maintenance savings) while locomotive and marine engines would experience a net cost (2.4 cents per gallon for the fuel and 1.1 cents per gallon for maintenance savings). Higher growth in nonroad fuel consumption relative to locomotive and marine fuel consumption eventually results in net negative costs of the 500 ppm fuel program (see Table 8.4-3 or Figure 8.7-1).

Table 8.7-1
Aggregate Cost per Ton for the 500 ppm Fuel Program
2004-2036 Net Present Values at 3% Discount Rate ($2001)

Item	Millions (except $/ton values)	Source
500 ppm gallons at $0.025/gal (2007-2010)	25,206	Table 8.4-2
500 ppm gallons at $0.024/gal (2010+)	203,483	Table 8.4-2
Fuel Cost	$5,514	Table 8.4-6
Net Maintenance Cost	-$5,009	Table 8.4-6
SOx Reduction	5,586	Table 8.6-1
Cost per Ton (with Maintenance Savings)	$90	Calculated
Cost per Ton (without Maintenance Savings)	$990	Calculated

8.7.2 Cost per Ton for the Proposed Program

The proposed program contains a two-step fuel program which is a reduction in sulfur levels for nonroad diesel fuel from current uncontrolled levels ultimately to 15 ppm, though we are proposing an interim cap of 500 ppm. Beginning June 1, 2007, refiners would therefore be required to produce nonroad, locomotive, and marine diesel fuel that meets a maximum sulfur level of 500 ppm. Then, beginning in June 1, 2010, fuel used for nonroad diesel applications (excluding locomotive and marine engines) is proposed to meet a maximum sulfur level of 15

ppm, since all 2011 and later model year nonroad diesel-fueled engines with aftertreatment must be refueled with this new low sulfur diesel fuel.

The costs of the proposal include costs associated with both steps in the fuel program and costs for the engine standards including equipment modifications. Maintenance costs and savings realized by both the existing fleet (nonroad, locomotive, and marine) and the new fleet of engines complying with the proposed standards are included. Figure 8.7-2 presents in graphic form the cost of the proposed program. These costs are also summarized in Table 8.5-1. The cost streams include the amortized capital (fixed) costs and variable costs.

Figure 8.7-2
Costs of the Proposed Fuel and Engine Program

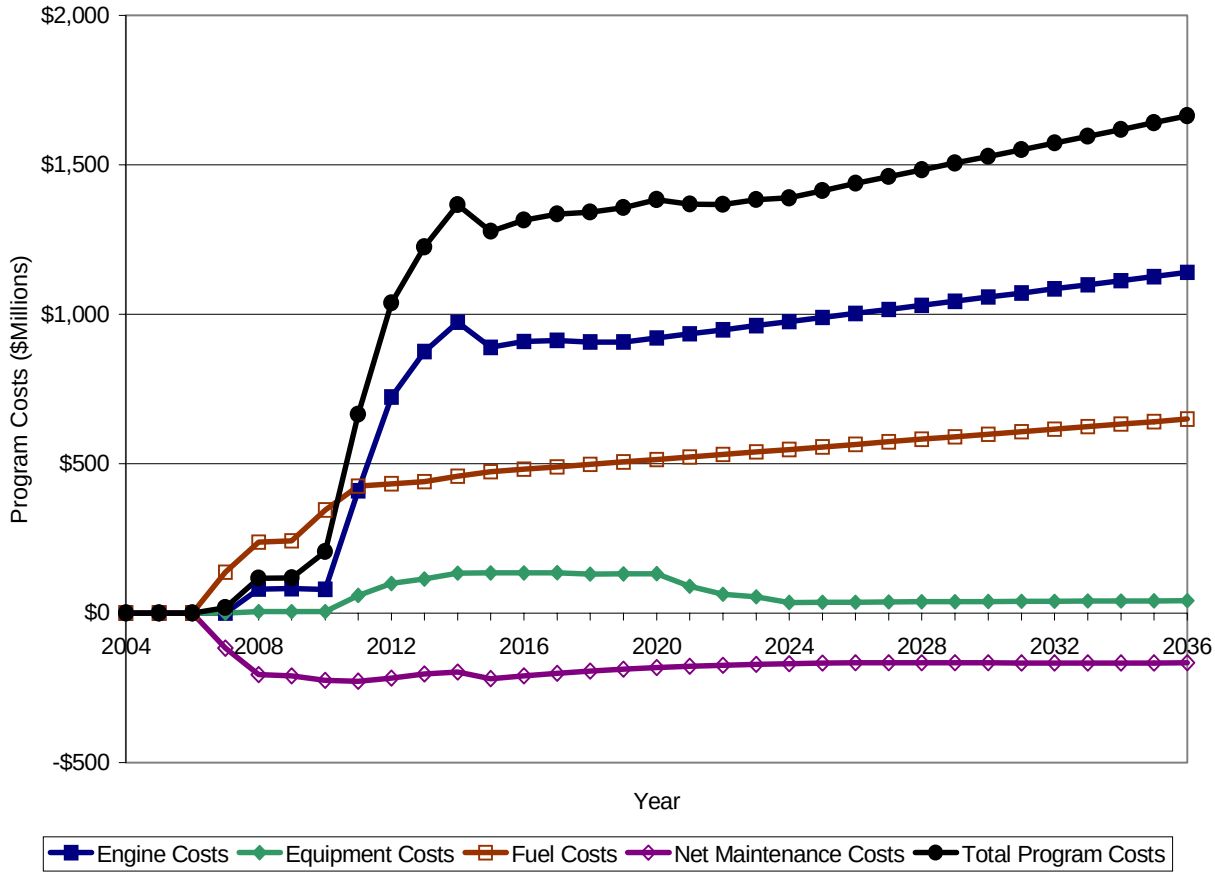


Figure 8.7-2 shows that total annual costs are estimated to be $120 million in the first year the new engine standards apply, increasing to $1.7 billion in 2036 as increasing numbers of engines become subject to the new standards and an ever increasing amount of fuel is consumed. As shown in Table 8.5-1, the net present value of a 30 year window from 2007 to 2036 is $20.7 billion.

The calculations of cost per ton of each emission reduced for the total program divides the net present value of the annual costs assigned to each pollutant (see Table 8.5-2 for costs by pollutant and Table 8.1-2 for how we have allocated costs by pollutant) by the net present value of the total annual reductions of each pollutant – NOx+NMHC, PM and SOx (see Table 8.6-1).

The net present value of the costs associated with each pollutant, calculated with a three percent discount rate, are shown in Table 8.5-1 as $6.4 billion for NOx+NMHC, $13.1 billion for PM and $1.2 billion for SO_x. The 30 year net present value, with a three percent discount rate, of emission reductions are 7.9 million tons for NOx+NMHC, 1.5 million tons for PM and 6.0 million tons for SO_x. Our air quality analysis and benefits analysis are found in Chapter 3 and Chapter 9, respectively.

The cost per ton of emissions reduced associated with the proposed engine and fuel program are calculated by dividing the net present value of the annualized costs of the program through 2036 by the net present value of the annual emission reductions through 2036. These results are shown in Table 8.7-2.

Table 8.7-2
Aggregate Cost per Ton for the Proposed Two-Step Fuel Program and Engine Program
2004-2036 Net Present Values at 3% Discount Rate ($2001)

Item	Millions (except $/ton values)	Source
500 ppm gallons at $0.025/gal (2007-2010)	25,206	Table 8.4-1
500 ppm gallons at $0.026/gal (2010-2014)	16,077	Table 8.4-1
500 ppm gallons at $0.024/gal (2014+)	54,791	Table 8.4-1
15 ppm gallons at $0.048/gal (2010-2014)	19,763	Table 8.4-1
15 ppm gallons at $0.048/gal (2014+)	112,851	Table 8.4-1
500 ppm Fuel Cost	$2,363	Table 8.4-5
15 ppm Fuel Cost	$6,366	Table 8.4-5
Net Maintenance Cost	-$3,445	Table 8.4-5
Engine Costs	$14,215	Table 8.5-1
Equipment Costs	$1,215	Table 8.5-1
Total Program Costs	$20,713	Table 8.5-1
NOx+NMHC Costs	$6,419	Table 8.5-2
PM Costs	$13,117	Table 8.5-2
SOx Costs	$1,177	Table 8.5-2
NOx+NMHC Reduction	7,909	Table 8.6-1
PM Reduction	1,501	Table 8.6-1
SOx Reduction	5,978	Table 8.6-1
Cost per Ton NOx+NMHC	$810	Calculated
Cost per Ton PM	$8,700	Calculated
Cost per Ton SOx	$200*	Calculated

* This result does not match that in Table 8.4-2 because the nonroad portion of the fuel is reduced to 15 ppm and does not stay at 500 (locomotive and marine portions are kept at 500ppm). The costs to reduce fuel sulfur from uncontrolled levels to 15ppm were assigned 50/50 to NOx+NMHC and PM because the reduction to 15 ppm is to enable aftertreatment technology.

We have also calculated the cost per ton of emissions in the year 2036 using the annual costs and emission reductions in that year alone. This number, shown in Table 8.7-3, approaches the long term cost per ton of emissions reduced after all fixed costs of the program have been recovered by industry leaving only the variable costs of control (and maintenance costs), and after most (though not all) of the pre-control fleet has been retired.

Table 8.7-3
Long Term Cost per Ton of the Proposed Two-Step Fuel Program and Engine Program
Annual Values without Discounting ($2001)

Pollutant	Long-Term Cost per Ton in 2036
NOx+NMHC	$530
PM	$6,900
SO_x	$170

Chapter 8 References

1. Power Systems Research, OELink Sales Version, 2002.

2. Nonroad Engine Growth Estimate, Report No. NR-008b, Docket Item II-A-32.

3. “Engine Sales Used in Proposed Nonroad Tier 4 Cost Analysis,” memorandum from Todd Sherwood to Public Docket No. A-2001-28.