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

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

This chapter aggregates the estimated incremental engine costs, operating costs, equipment costs, and fuel costs of the final rule. This chapter also presents detailed information on the calculation for the cost per ton of pollutant. Chapter 6 details the estimated fixed and variable costs for modifying new nonroad engines and equipment to meet new emission standards; Chapter 6 also discusses the effects of the new low-sulfur diesel fuels on operating costs for land-based nonroad diesel engines, locomotive engines, and marine diesel engines. Chapter 7 describes our estimates of the costs associated with the fuel requirements in this final rule.

We have calculated the cost per ton of emission reductions for this final rule based on the net present value of all costs incurred and all emission reductions generated over a 30-year time window after the program takes effect. This approach captures all the costs and emission reductions from the final rule, including those costs incurred and emission reductions generated by the existing fleet. 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 is meant to capture both the early period of the program when there are a small number of compliant engines in the fleet, and the later period when there is nearly complete turnover to compliant engines. Note that all costs and emission reductions presented here are 30-year numbers (the net present values in 2004 of the stream of costs/reductions occurring from 2007 through 2036, expressed in $2002).

While there is a broad consensus among economists that future benefits and costs of regulatory programs should be discounted, there is no consensus in the literature regarding the most appropriate discounting concept and rate to apply. In particular, the theoretical literature is divided between two alternative approaches. The first approach is referred to as the "demand-side approach" (see Arrow et al, 1996), which defines the appropriate discount rate as the rate at which society would collectively trade off current versus future consumption. This rate is difficult to establish empirically, but estimates in the literature commonly range from 1 to 4 percent. EPA's economic Guidelines suggest using a value of two to three percent.[1] The second approach is referred to as the "cost-side approach" (see Lind, 1982), and discount rates associated with this concept reflect trade-offs between current and future consumption derived by market rates driven by the marginal productivity of capital. This rate is also difficult to derive from empirical data, but estimates typically fall in the range of 4 to 10 percent. OMB's circular A-94 expresses a preference for the cost-side approach and specifies a seven percent rate.

Given both the lack of consensus in the literature on the most appropriate concept and the uncertainty surrounding the associated empirical estimates, EPA's Economic Guidelines and the two key outside expert groups which advise EPA on economic analytical issues all recommend evaluating benefits and costs using a range of discount rates. Consistent with this advice, we have analyzed the benefits and costs of the nonroad Tier 4 rule using both a three percent rate and a seven percent rate. We present the results based on a three percent discount rate as our primary estimates.

## 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.[2, 3] The PSR database has been used as the basis for our current fleet mix; i.e., which equipment types were sold in 2000 and with engines from which power category. The sales estimates and growth rates used throughout this analysis are shown in Table 8.1-1.[4]

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

| Power range | 2000 Model Year Sales | Annual Growth in Engines Sold | Linear Growth Rate |
|---|---|---|---|
| 0<hp<25 | 119,159 | 4,116 | 3.5% |
| 25≤hp<50 | 132,981 | 3,505 | 2.6% |
| 50≤hp<75 | 93,914 | 2,046 | 2.2% |
| 75≤hp<100 | 68,665 | 1,499 | 2.2% |
| 100≤hp<175 | 112,340 | 2,321 | 2.1% |
| 175≤hp<300 | 61,851 | 1,414 | 2.3% |
| 300≤hp<600 | 34,095 | 436 | 1.3% |
| 600≤hp≤750 | 2,752 | 50 | 1.8% |
| hp>750 | 2,785 | 51 | 1.8% |
| Total | 628,542 | 15,438 | 2.5% |

Because the new emission standards will reduce emissions of several different pollutants (i.e., NOx, PM, NMHC, and SOx), we have attempted to allocate the estimated costs to emission reductions of specific pollutants. This apportionment of costs by pollutant allows us to calculate the average cost per ton of emission reduction resulting from this rule. Table 8.1-2 summarizes the allocations we have used in the final rule. 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.[A] For fuel-related costs where no technology enablement occurs (i.e., fuel-derived emissions

[A] A CDPF is a catalyzed diesel particulate filter; a DOC is a diesel oxidation catalyst; CCV is a closed crankcase ventilation system; Regen is short for regeneration; EGR is exhaust gas recirculation; NRLM refers to nonroad, locomotive, and marine.

reductions where no new engine standards exist that rely on the new fuel), we have apportioned one-third of the costs to PM and two-thirds to SOx. This is different than how we allocated costs in the proposal where we allocated 100 percent of such costs to SOx control. We believe the allocation used here is more appropriate given that the lower sulfur fuel provides for substantial PM reductions even without new engine standards.[B] The estimated costs for 15 ppm fuel are apportioned one-half to technology enablement (i.e., engine-derived emissions reductions) and one-half to fuel-derived emissions reductions. Respectively, these halves are allocated 50%/50% to NOx+NMHC/PM and 33%/67% to PM/SOx. This latter split is consistent with the fuel-derived allocation described above. This is different than the proposal where we allocated 15 ppm costs entirely to technology enablement. We believe the allocations used here in the final rule are more appropriate given the substantial PM and SOx reductions that occur solely because the fuel sulfur level has been reduced. We note throughout the discussion to which pollutant we have attributed costs.

## 8.2 Aggregate Engine Costs

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

### 8.2.1 Aggregate Engine Fixed Costs

Chapter 6 presents the aggregate engine fixed costs, along with our best estimate of how those costs might be recovered (i.e., on which engines), for engine R&D, tooling, and certification, respectively (see Tables 6.2-4, 6.2-6, and 6.2-8).[C] Table 8.2-1 presents the combined total of all engine fixed costs in the indicated years for each power category. Table 8.2-2 shows to what pollutant the total costs by year are allocated. 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 (for example, costs associated with the 2008 standards and costs associated with the 2013 standards for 50 to 75 hp engines). Therefore, the costs presented in Table 8.2-2 for PM do 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

[B] A 50/50 split between PM/SOx could be argued, but that seems inappropriate given that 98 percent of fuel borne sulfur is exhausted as SOx and only two percent is exhausted as PM. Given that, a 2/98 split between PM/SOx could be argued, but that seems inappropriate given the importance of PM reductions—which have much higher human health benefits—relative to SOx reductions. The 33/67 split between PM/SOx that we have chosen here seems to provide an appropriate balance.

[C] We have estimated a “recovered” cost for all engine and equipment fixed costs to present a per-production-unit analysis of the cost of the final rule (see Section 6.4.3 or Chapter 10 for our estimate of engine costs on a per-unit basis). In general, in environmental economics, it is more conventional to simply count the total costs of the program (i.e., opportunity costs) in the year they occur. However, this approach does not directly estimate a per-unit cost, since fixed costs occur before the standards take effect, resulting in costs that do not correspond to units certified to the new emission standards. 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 interest rate to reflect the time value of money (i.e., the lost opportunity cost of that capital).

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.

Table 8.1-2
Summary of How Cost are Allocated Among Pollutants under the NRT4 Final Program

| Item | | NOx+NMHC | PM | SOx |
|---|---|---|---|---|
| Fuel Costs – incremental cent/gallon | 500 ppm Affected NRLM | | 33% | 67% |
| | 15 ppm Affected NR | 50% of 50% | 50% of 50%<br>33% of 50% | 67% of 50% |
| | 15 ppm Affected L&M | | 33% | 67% |
| Operating Costs – Oil-Change Savings | 500 ppm Affected NRLM | | 33% | 67% |
| | 15 ppm Affected NR | 50% of 50% | 50% of 50%<br>33% of 50% | 67% of 50% |
| | 15 ppm Affected L&M | | 33% | 67% |
| Operating Costs – CDPF Maintenance | 15 ppm NR in new CDPF engines | | 100% | |
| Operating Costs – CDPF Regen (FE impact) | 15 ppm NR in new CDPF engines | | 100% | |
| Operating Costs – CCV Maintenance | All NR in new CCV engines | 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 2008 | | 100% | |
| | 25-50 hp 2013 | 50% | 50% | |
| | 50-75 hp 2013 | | 100% | |
| | 75-750 hp at start of phase-in | 50% | 50% | |
| | 75-750 hp at end of phase-in | 100% | | |
| | >750 hp | 50% | 50% | |
| Equipment Variable Costs | <25 hp; 25-75 hp 2008-2012 | | 100% | |
| | 25-50 hp 2013+ | 50% | 50% | |
| | 50-75 hp 2013+ | | 100% | |
| | 75-750 hp at start of phase-in[b] | 25% | 75% | |
| | 75-750 hp at end of phase-in | 50% | 50% | |
| | >750 hp | | 100% | |
| Equipment Fixed Costs | <75 hp 2008 standards | | 100% | |
| | 25-75 hp 2013 standards | 50% | 50% | |
| | 75-750 hp at start of phase-in | 50% | 50% | |
| | 75-750 hp at end of phase-in | 100% | | |
| | >750 hp 2011 | 100% | | |
| | >750 hp 2015 | | 100% | |

[b] All engines meet the new PM standard and half meet the new NOx standard. For NOx phase-in engines, the allocation is 50/50 to PM/NOx. For PM-only engines, the allocation is 100% PM. The resultant allocation is 75/25 to PM/NOx.

8.2-1
Aggregate Engine Fixed Costs by Power Category
($Millions of 2002 dollars)

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | $ 5.8 | $ 8.0 | $ 5.5 | $ - | $ - | $ - | $ - | $ - | $ - | $ 19.3 |
| 2009 | $ 5.8 | $ 8.0 | $ 5.5 | $ - | $ - | $ - | $ - | $ - | $ - | $ 19.3 |
| 2010 | $ 5.8 | $ 8.0 | $ 5.5 | $ - | $ - | $ - | $ - | $ - | $ - | $ 19.3 |
| 2011 | $ 5.8 | $ 8.0 | $ 5.5 | $ - | $ - | $ 17.4 | $ 20.5 | $ 3.8 | $ 1.9 | $ 62.9 |
| 2012 | $ 5.8 | $ 8.0 | $ 5.5 | $ 6.9 | $ 10.9 | $ 17.4 | $ 20.5 | $ 3.8 | $ 1.9 | $ 80.7 |
| 2013 | $ - | $ 13.3 | $ 9.2 | $ 6.9 | $ 10.9 | $ 17.4 | $ 20.5 | $ 3.8 | $ 1.9 | $ 83.8 |
| 2014 | $ - | $ 13.3 | $ 9.2 | $ 9.6 | $ 15.4 | $ 23.7 | $ 29.5 | $ 5.6 | $ 1.9 | $ 108.2 |
| 2015 | $ - | $ 13.3 | $ 9.2 | $ 9.6 | $ 15.4 | $ 23.7 | $ 29.5 | $ 5.6 | $ 5.1 | $ 111.4 |
| 2016 | $ - | $ 13.3 | $ 9.2 | $ 9.6 | $ 15.4 | $ 6.3 | $ 9.0 | $ 1.8 | $ 3.2 | $ 67.8 |
| 2017 | $ - | $ 13.3 | $ 9.2 | $ 2.7 | $ 4.5 | $ 6.3 | $ 9.0 | $ 1.8 | $ 3.2 | $ 50.0 |
| 2018 | $ - | $ - | $ - | $ 2.7 | $ 4.5 | $ 6.3 | $ 9.0 | $ 1.8 | $ 3.2 | $ 27.6 |
| 2019 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ 3.2 | $ 3.2 |
| 2020 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Total | $ 28.8 | $ 106.1 | $ 73.5 | $ 48.2 | $ 77.0 | $ 118.3 | $ 147.7 | $ 28.1 | $ 25.7 | $ 653.4 |
| 30 Yr NPV at 3% | $ 24.2 | $ 81.3 | $ 56.3 | $ 35.3 | $ 56.4 | $ 88.7 | $ 110.3 | $ 21.0 | $ 18.3 | $ 491.8 |
| 30 Yr NPV at 7% | $ 19.3 | $ 58.3 | $ 40.4 | $ 23.7 | $ 37.9 | $ 61.5 | $ 76.2 | $ 14.5 | $ 11.9 | $ 343.6 |

Table 8.2-2
Aggregate Engine Fixed Costs by Pollutant
($Millions of 2002 dollars)

| Year | Recovery of PM Costs | Recovery of NOx Costs | Recovery of Fixed Costs |
|---|---|---|---|
| 2008 | $ 19.3 | $ - | $ 19.3 |
| 2009 | $ 19.3 | $ - | $ 19.3 |
| 2010 | $ 19.3 | $ - | $ 19.3 |
| 2011 | $ 40.9 | $ 22.0 | $ 62.9 |
| 2012 | $ 49.8 | $ 30.9 | $ 80.7 |
| 2013 | $ 51.3 | $ 32.5 | $ 83.8 |
| 2014 | $ 51.3 | $ 56.9 | $ 108.2 |
| 2015 | $ 54.1 | $ 57.3 | $ 111.4 |
| 2016 | $ 32.5 | $ 35.3 | $ 67.8 |
| 2017 | $ 23.6 | $ 26.4 | $ 50.0 |
| 2018 | $ 2.8 | $ 24.8 | $ 27.6 |
| 2019 | $ 2.8 | $ 0.4 | $ 3.2 |
| 2020 | $ - | $ - | $ - |
| Total | $ 366.9 | $ 286.4 | $ 653.4 |
| 30 Yr NPV at 3% | $ 281.6 | $ 210.3 | $ 491.8 |
| 30 Yr NPV at 7% | $ 201.8 | $ 141.9 | $ 343.6 |

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, with the exception of R&D for the 2008 standards which occurs over a four-year span preceding the standards as described in Chapter 6. Where a phase-in exists (for example, for NOx standards on engines between 75 and 750 hp), expenditures are assumed to occur over the five years preceding the first year that NOx adsorbers will be introduced, then continuing during the phase-in years; the expenditures will be incurred 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 include a cost of seven percent when amortizing engine R&D expenditures.

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 after the new standards take effect; we include a cost of seven percent when amortizing engine tooling costs.

We have calculated the net present value of the engine fixed costs over the 30-year period following implementation of the program as $492 million. This value assumes a three percent social discount rate.

### 8.2.2 Aggregate Engine Variable Costs

Engine variable costs are discussed in detail in Section 6.2.2. 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 8.2-3 and 8.2-4 (refer to Table 8.1-2 for how costs have been allocated to PM and NOx). Because of their nature, variable costs are proportional to engine sales and are projected to increase in the future as engine sales increase. We have calculated the net present value of the engine variable costs over the 30-year period following implementation of the program as \$13.6 billion. This value assumes a three percent social discount rate.

Table 8.2-3
Aggregate Engine Variable Costs by Power Category ($Millions of 2002 dollars)

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | $ 19.7 | $ 23.7 | $ 18.4 | $ - | $ - | $ - | $ - | $ - | $ - | $ 61.8 |
| 2009 | $ 20.2 | $ 24.2 | $ 18.8 | $ - | $ - | $ - | $ - | $ - | $ - | $ 63.2 |
| 2010 | $ 19.7 | $ 23.4 | $ 18.0 | $ - | $ - | $ - | $ - | $ - | $ - | $ 61.1 |
| 2011 | $ 20.2 | $ 23.9 | $ 18.4 | $ - | $ - | $ 153.4 | $ 101.5 | $ 16.3 | $ 6.6 | $ 340.2 |
| 2012 | $ 20.7 | $ 24.4 | $ 18.7 | $ 98.2 | $ 192.8 | $ 156.2 | $ 102.6 | $ 16.6 | $ 6.7 | $ 636.8 |
| 2013 | $ 21.2 | $ 158.4 | $ 100.9 | $ 99.9 | $ 196.0 | $ 123.2 | $ 80.4 | $ 13.0 | $ 5.3 | $ 798.3 |
| 2014 | $ 21.7 | $ 161.5 | $ 102.6 | $ 100.6 | $ 195.6 | $ 158.1 | $ 102.3 | $ 16.6 | $ 5.4 | $ 864.4 |
| 2015 | $ 22.2 | $ 125.3 | $ 79.3 | $ 102.2 | $ 198.8 | $ 160.9 | $ 103.4 | $ 16.8 | $ 29.6 | $ 838.5 |
| 2016 | $ 22.7 | $ 127.7 | $ 80.6 | $ 103.9 | $ 201.9 | $ 163.6 | $ 104.5 | $ 17.1 | $ 30.0 | $ 852.0 |
| 2017 | $ 23.2 | $ 130.0 | $ 81.9 | $ 105.6 | $ 205.0 | $ 166.3 | $ 105.6 | $ 17.3 | $ 24.6 | $ 859.6 |
| 2018 | $ 23.7 | $ 132.4 | $ 83.2 | $ 107.3 | $ 208.2 | $ 169.1 | $ 106.7 | $ 17.6 | $ 24.9 | $ 873.1 |
| 2019 | $ 24.2 | $ 134.8 | $ 84.5 | $ 109.0 | $ 211.3 | $ 171.8 | $ 107.8 | $ 17.8 | $ 25.3 | $ 886.5 |
| 2020 | $ 24.7 | $ 137.1 | $ 85.8 | $ 110.7 | $ 214.4 | $ 174.6 | $ 109.0 | $ 18.0 | $ 25.6 | $ 899.9 |
| 2021 | $ 25.2 | $ 139.5 | $ 87.1 | $ 112.3 | $ 217.6 | $ 177.3 | $ 110.1 | $ 18.3 | $ 26.0 | $ 913.3 |
| 2022 | $ 25.7 | $ 141.9 | $ 88.4 | $ 114.0 | $ 220.7 | $ 180.0 | $ 111.2 | $ 18.5 | $ 26.3 | $ 926.8 |
| 2023 | $ 26.2 | $ 144.2 | $ 89.7 | $ 115.7 | $ 223.8 | $ 182.8 | $ 112.3 | $ 18.8 | $ 26.7 | $ 940.2 |
| 2024 | $ 26.8 | $ 146.6 | $ 91.0 | $ 117.4 | $ 227.0 | $ 185.5 | $ 113.4 | $ 19.0 | $ 27.0 | $ 953.6 |
| 2025 | $ 27.3 | $ 149.0 | $ 92.3 | $ 119.1 | $ 230.1 | $ 188.2 | $ 114.5 | $ 19.2 | $ 27.3 | $ 967.0 |
| 2026 | $ 27.8 | $ 151.3 | $ 93.6 | $ 120.7 | $ 233.2 | $ 191.0 | $ 115.6 | $ 19.5 | $ 27.7 | $ 980.4 |
| 2027 | $ 28.3 | $ 153.7 | $ 94.9 | $ 122.4 | $ 236.4 | $ 193.7 | $ 116.7 | $ 19.7 | $ 28.0 | $ 993.9 |
| 2028 | $ 28.8 | $ 156.1 | $ 96.2 | $ 124.1 | $ 239.5 | $ 196.5 | $ 117.8 | $ 20.0 | $ 28.4 | $ 1,007.3 |
| 2029 | $ 29.3 | $ 158.4 | $ 97.5 | $ 125.8 | $ 242.6 | $ 199.2 | $ 118.9 | $ 20.2 | $ 28.7 | $ 1,020.7 |
| 2030 | $ 29.8 | $ 160.8 | $ 98.8 | $ 127.5 | $ 245.8 | $ 201.9 | $ 120.1 | $ 20.4 | $ 29.1 | $ 1,034.1 |
| 2031 | $ 30.3 | $ 163.2 | $ 100.1 | $ 129.2 | $ 248.9 | $ 204.7 | $ 121.2 | $ 20.7 | $ 29.4 | $ 1,047.6 |
| 2032 | $ 30.8 | $ 165.5 | $ 101.4 | $ 130.8 | $ 252.0 | $ 207.4 | $ 122.3 | $ 20.9 | $ 29.7 | $ 1,061.0 |
| 2033 | $ 31.3 | $ 167.9 | $ 102.7 | $ 132.5 | $ 255.2 | $ 210.2 | $ 123.4 | $ 21.2 | $ 30.1 | $ 1,074.4 |
| 2034 | $ 31.8 | $ 170.3 | $ 104.0 | $ 134.2 | $ 258.3 | $ 212.9 | $ 124.5 | $ 21.4 | $ 30.4 | $ 1,087.8 |
| 2035 | $ 32.3 | $ 172.6 | $ 105.3 | $ 135.9 | $ 261.5 | $ 215.6 | $ 125.6 | $ 21.6 | $ 30.8 | $ 1,101.2 |
| 2036 | $ 32.8 | $ 175.0 | $ 106.6 | $ 137.6 | $ 264.6 | $ 218.4 | $ 126.7 | $ 21.9 | $ 31.1 | $ 1,114.7 |
| 30 Yr NPV at 3% | $ 435.7 | $ 2,089.2 | $ 1,315.1 | $ 1,627.3 | $ 3,151.4 | $ 2,670.3 | $ 1,650.1 | $ 274.9 | $ 348.3 | $ 13,562.1 |
| 30 Yr NPV at 7% | $ 236.9 | $ 1,057.6 | $ 672.3 | $ 812.0 | $ 1,574.6 | $ 1,359.6 | $ 849.2 | $ 140.6 | $ 168.5 | $ 6,871.3 |

Table 8.2-4
Aggregate Engine Variable Costs by Technology and by Pollutant ($Millions of 2002 dollars)

| Year | Fuel System | Cooled EGR | CCV | DOC | CDPF System | CDPF Regen System | NOx Adsorber System | Total PM Costs | Total NOx+NMHC Costs | Total Costs |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | $ - | $ - | $ 0.5 | $ 61.2 | $ - | $ - | $ - | $ 61.5 | $ 0.3 | $ 61.8 |
| 2009 | $ - | $ - | $ 0.6 | $ 62.6 | $ - | $ - | $ - | $ 62.9 | $ 0.3 | $ 63.2 |
| 2010 | $ - | $ - | $ 0.4 | $ 60.7 | $ - | $ - | $ - | $ 60.9 | $ 0.2 | $ 61.1 |
| 2011 | $ - | $ 6.2 | $ 7.1 | $ 62.0 | $ 168.8 | $ 28.7 | $ 67.4 | $ 263.1 | $ 77.1 | $ 340.2 |
| 2012 | $ - | $ 6.3 | $ 13.4 | $ 63.3 | $ 338.4 | $ 73.2 | $ 142.1 | $ 481.7 | $ 155.1 | $ 636.8 |
| 2013 | $ 53.3 | $ 29.2 | $ 11.8 | $ 21.2 | $ 414.1 | $ 137.4 | $ 131.2 | $ 605.3 | $ 193.0 | $ 798.3 |
| 2014 | $ 54.3 | $ 29.8 | $ 10.3 | $ 21.7 | $ 380.3 | $ 128.8 | $ 239.3 | $ 563.1 | $ 301.4 | $ 864.4 |
| 2015 | $ 41.6 | $ 24.4 | $ 10.4 | $ 22.2 | $ 381.3 | $ 115.6 | $ 243.0 | $ 545.1 | $ 293.4 | $ 838.5 |
| 2016 | $ 42.4 | $ 24.8 | $ 10.6 | $ 22.7 | $ 387.3 | $ 117.5 | $ 246.8 | $ 554.0 | $ 298.0 | $ 852.0 |
| 2017 | $ 43.1 | $ 25.2 | $ 10.8 | $ 23.2 | $ 388.0 | $ 118.9 | $ 250.5 | $ 557.0 | $ 302.6 | $ 859.6 |
| 2018 | $ 43.8 | $ 25.7 | $ 10.9 | $ 23.7 | $ 393.9 | $ 120.8 | $ 254.2 | $ 565.8 | $ 307.2 | $ 873.1 |
| 2019 | $ 44.6 | $ 26.1 | $ 11.1 | $ 24.2 | $ 399.8 | $ 122.8 | $ 257.9 | $ 574.6 | $ 311.9 | $ 886.5 |
| 2020 | $ 45.3 | $ 26.5 | $ 11.2 | $ 24.7 | $ 405.7 | $ 124.7 | $ 261.6 | $ 583.4 | $ 316.5 | $ 899.9 |
| 2021 | $ 46.1 | $ 27.0 | $ 11.4 | $ 25.2 | $ 411.7 | $ 126.6 | $ 265.4 | $ 592.3 | $ 321.1 | $ 913.3 |
| 2022 | $ 46.8 | $ 27.4 | $ 11.6 | $ 25.7 | $ 417.6 | $ 128.5 | $ 269.1 | $ 601.1 | $ 325.7 | $ 926.8 |
| 2023 | $ 47.6 | $ 27.8 | $ 11.7 | $ 26.2 | $ 423.5 | $ 130.5 | $ 272.8 | $ 609.9 | $ 330.3 | $ 940.2 |
| 2024 | $ 48.3 | $ 28.3 | $ 11.9 | $ 26.8 | $ 429.5 | $ 132.4 | $ 276.5 | $ 618.7 | $ 334.9 | $ 953.6 |
| 2025 | $ 49.1 | $ 28.7 | $ 12.0 | $ 27.3 | $ 435.4 | $ 134.3 | $ 280.2 | $ 627.5 | $ 339.5 | $ 967.0 |
| 2026 | $ 49.8 | $ 29.2 | $ 12.2 | $ 27.8 | $ 441.3 | $ 136.2 | $ 284.0 | $ 636.3 | $ 344.1 | $ 980.4 |
| 2027 | $ 50.5 | $ 29.6 | $ 12.4 | $ 28.3 | $ 447.3 | $ 138.2 | $ 287.7 | $ 645.1 | $ 348.7 | $ 993.9 |
| 2028 | $ 51.3 | $ 30.0 | $ 12.5 | $ 28.8 | $ 453.2 | $ 140.1 | $ 291.4 | $ 653.9 | $ 353.3 | $ 1,007.3 |
| 2029 | $ 52.0 | $ 30.5 | $ 12.7 | $ 29.3 | $ 459.1 | $ 142.0 | $ 295.1 | $ 662.8 | $ 358.0 | $ 1,020.7 |
| 2030 | $ 52.8 | $ 30.9 | $ 12.8 | $ 29.8 | $ 465.1 | $ 143.9 | $ 298.8 | $ 671.6 | $ 362.6 | $ 1,034.1 |
| 2031 | $ 53.5 | $ 31.3 | $ 13.0 | $ 30.3 | $ 471.0 | $ 145.8 | $ 302.6 | $ 680.4 | $ 367.2 | $ 1,047.6 |
| 2032 | $ 54.3 | $ 31.8 | $ 13.2 | $ 30.8 | $ 476.9 | $ 147.8 | $ 306.3 | $ 689.2 | $ 371.8 | $ 1,061.0 |
| 2033 | $ 55.0 | $ 32.2 | $ 13.3 | $ 31.3 | $ 482.8 | $ 149.7 | $ 310.0 | $ 698.0 | $ 376.4 | $ 1,074.4 |
| 2034 | $ 55.8 | $ 32.7 | $ 13.5 | $ 31.8 | $ 488.8 | $ 151.6 | $ 313.7 | $ 706.8 | $ 381.0 | $ 1,087.8 |
| 2035 | $ 56.5 | $ 33.1 | $ 13.6 | $ 32.3 | $ 494.7 | $ 153.5 | $ 317.5 | $ 715.6 | $ 385.6 | $ 1,101.2 |
| 2036 | $ 57.2 | $ 33.5 | $ 13.8 | $ 32.8 | $ 500.6 | $ 155.5 | $ 321.2 | $ 724.4 | $ 390.2 | $ 1,114.7 |
| 30 Yr NPV at 3% | $ 657.0 | $ 391.7 | $ 175.8 | $ 611.1 | $ 6,127.5 | $ 1,860.1 | $ 3,738.8 | $ 9,015.3 | $ 4,546.9 | $ 13,562.1 |
| 30 Yr NPV at 7% | $ 323.5 | $ 194.8 | $ 90.7 | $ 377.0 | $ 3,102.8 | $ 933.3 | $ 1,849.0 | $ 4,620.3 | $ 2,251.0 | $ 6,871.3 |

## 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 Table 8.3-2 shows to what pollutant these costs are attributed. Note that the cost allocations shown in Table 8.3-2 are not generated assuming any simple split of costs between NOx and PM control. Some equipment fixed costs are solely attributed to PM control (for example, costs associated with the 2008 standards and costs associated with the 2013 standards for 50 to 75 hp engines). The costs presented in Table 8.3-1 for PM therefore do 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.

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 (for example, for NOx standards on engines over 75 hp engines), expenditures are assumed to occur over the two years preceding the first year that NOx adsorbers will be introduced, then continuing during the phase-in years; the expenditures will be incurred 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 include a cost of seven percent when amortizing equipment fixed costs.

We have calculated the net present value of the equipment fixed costs over the 30-year period following implementation of the program as $847 million. This value assumes a three percent social discount rate.

Table 8.3-1
Aggregate Equipment Fixed Costs by Power Range ($Millions of 2002 dollars)

| Year Recovered | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | $ 2.3 | $ 1.3 | $ 0.9 | $ - | $ - | $ - | $ - | $ - | $ - | $ 4.5 |
| 2009 | $ 2.3 | $ 1.3 | $ 0.9 | $ - | $ - | $ - | $ - | $ - | $ - | $ 4.5 |
| 2010 | $ 2.3 | $ 1.3 | $ 0.9 | $ - | $ - | $ - | $ - | $ - | $ - | $ 4.5 |
| 2011 | $ 2.3 | $ 1.3 | $ 0.9 | $ - | $ - | $ 23.4 | $ 20.6 | $ 4.0 | $ 0.6 | $ 53.1 |
| 2012 | $ 2.3 | $ 1.3 | $ 0.9 | $ 9.4 | $ 23.9 | $ 23.4 | $ 20.6 | $ 4.0 | $ 0.6 | $ 86.4 |
| 2013 | $ 2.3 | $ 7.5 | $ 5.3 | $ 9.4 | $ 23.9 | $ 23.4 | $ 20.6 | $ 4.0 | $ 0.6 | $ 97.0 |
| 2014 | $ 2.3 | $ 7.5 | $ 5.3 | $ 11.9 | $ 30.0 | $ 29.4 | $ 25.8 | $ 5.0 | $ 0.6 | $ 117.7 |
| 2015 | $ 2.3 | $ 7.5 | $ 5.3 | $ 11.9 | $ 30.0 | $ 29.4 | $ 25.8 | $ 5.0 | $ 4.9 | $ 122.0 |
| 2016 | $ 2.3 | $ 7.5 | $ 5.3 | $ 11.9 | $ 30.0 | $ 29.4 | $ 25.8 | $ 5.0 | $ 4.9 | $ 122.0 |
| 2017 | $ 2.3 | $ 7.5 | $ 5.3 | $ 11.9 | $ 30.0 | $ 29.4 | $ 25.8 | $ 5.0 | $ 4.9 | $ 122.0 |
| 2018 | $ - | $ 6.2 | $ 4.4 | $ 11.9 | $ 30.0 | $ 29.4 | $ 25.8 | $ 5.0 | $ 4.9 | $ 117.5 |
| 2019 | $ - | $ 6.2 | $ 4.4 | $ 11.9 | $ 30.0 | $ 29.4 | $ 25.8 | $ 5.0 | $ 4.9 | $ 117.5 |
| 2020 | $ - | $ 6.2 | $ 4.4 | $ 11.9 | $ 30.0 | $ 29.4 | $ 25.8 | $ 5.0 | $ 4.9 | $ 117.5 |
| 2021 | $ - | $ 6.2 | $ 4.4 | $ 11.9 | $ 30.0 | $ 6.0 | $ 5.2 | $ 1.0 | $ 4.3 | $ 68.9 |
| 2022 | $ - | $ 6.2 | $ 4.4 | $ 2.4 | $ 6.1 | $ 6.0 | $ 5.2 | $ 1.0 | $ 4.3 | $ 35.6 |
| 2023 | $ - | $ - | $ - | $ 2.4 | $ 6.1 | $ 6.0 | $ 5.2 | $ 1.0 | $ 4.3 | $ 25.0 |
| 2024 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ 4.3 | $ 4.3 |
| Total | $ 23.0 | $ 75.0 | $ 52.9 | $ 118.6 | $ 299.7 | $ 293.6 | $ 258.0 | $ 50.1 | $ 48.9 | $ 1,219.9 |
| 30 Yr NPV at 3% | $ 18.0 | $ 51.9 | $ 36.6 | $ 81.3 | $ 205.5 | $ 206.1 | $ 181.2 | $ 35.2 | $ 31.5 | $ 847.2 |
| 30 Yr NPV at 7% | $ 13.2 | $ 32.8 | $ 23.1 | $ 50.5 | $ 127.7 | $ 132.3 | $ 116.3 | $ 22.6 | $ 18.1 | $ 536.6 |

Table 8.3-2
Aggregate Equipment Fixed Costs by Pollutant
($Millions of 2002 dollars)

| Year | Recovery of PM Costs | Recovery of NOx+NMHC Costs | Recovery of Fixed Costs |
|---|---|---|---|
| 2008 | $ 4.5 | $ - | $ 4.5 |
| 2009 | $ 4.5 | $ - | $ 4.5 |
| 2010 | $ 4.5 | $ - | $ 4.5 |
| 2011 | $ 28.5 | $ 24.6 | $ 53.1 |
| 2012 | $ 45.1 | $ 41.2 | $ 86.4 |
| 2013 | $ 50.4 | $ 46.5 | $ 97.0 |
| 2014 | $ 50.4 | $ 67.3 | $ 117.7 |
| 2015 | $ 54.7 | $ 67.3 | $ 122.0 |
| 2016 | $ 54.7 | $ 67.3 | $ 122.0 |
| 2017 | $ 54.7 | $ 67.3 | $ 122.0 |
| 2018 | $ 50.2 | $ 67.3 | $ 117.5 |
| 2019 | $ 50.2 | $ 67.3 | $ 117.5 |
| 2020 | $ 50.2 | $ 67.3 | $ 117.5 |
| 2021 | $ 26.2 | $ 42.7 | $ 68.9 |
| 2022 | $ 9.6 | $ 26.0 | $ 35.6 |
| 2023 | $ 4.3 | $ 20.7 | $ 25.0 |
| 2024 | $ 4.3 | $ - | $ 4.3 |
| Total | $ 547.3 | $ 672.5 | $ 1,219.9 |
| 30 Yr NPV at 3% | $ 384.9 | $ 462.2 | $ 847.2 |
| 30 Yr NPV at 7% | $ 247.9 | $ 288.7 | $ 536.6 |

### 8.3.2 Aggregate Equipment Variable Costs

The equipment variable costs, such as sheet metal costs, mounting hardware, and labor, were estimated by power category in Section 6.3. The aggregate equipment variable costs through 2036 are presented in Table 8.3-3. Table 8.3-4 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). We have calculated the net present value of the equipment variable costs over the 30-year period following implementation of the program as $434 million. This value assumes a three percent social discount rate.

Table 8.3-3
Aggregate Equipment Variable Costs by Power Category ($Millions of 2002 dollars)

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| 2009 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| 2010 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| 2011 | $ - | $ - | $ - | $ - | $ - | $ 4.5 | $ 4.3 | $ 0.4 | $ - | $ 9.1 |
| 2012 | $ - | $ - | $ - | $ 3.9 | $ 6.4 | $ 4.6 | $ 4.3 | $ 0.4 | $ - | $ 19.6 |
| 2013 | $ - | $ 3.6 | $ 2.5 | $ 4.0 | $ 6.5 | $ 3.7 | $ 3.5 | $ 0.3 | $ - | $ 24.2 |
| 2014 | $ - | $ 3.7 | $ 2.6 | $ 4.3 | $ 7.1 | $ 5.0 | $ 4.7 | $ 0.4 | $ - | $ 27.9 |
| 2015 | $ - | $ 3.0 | $ 2.1 | $ 4.4 | $ 7.2 | $ 5.1 | $ 4.8 | $ 0.4 | $ 0.4 | $ 27.5 |
| 2016 | $ - | $ 3.1 | $ 2.1 | $ 4.5 | $ 7.3 | $ 5.2 | $ 4.8 | $ 0.4 | $ 0.4 | $ 27.9 |
| 2017 | $ - | $ 3.1 | $ 2.2 | $ 4.5 | $ 7.4 | $ 5.3 | $ 4.9 | $ 0.4 | $ 0.4 | $ 28.2 |
| 2018 | $ - | $ 3.2 | $ 2.2 | $ 4.6 | $ 7.6 | $ 5.4 | $ 4.9 | $ 0.5 | $ 0.4 | $ 28.7 |
| 2019 | $ - | $ 3.3 | $ 2.2 | $ 4.7 | $ 7.7 | $ 5.5 | $ 5.0 | $ 0.5 | $ 0.4 | $ 29.1 |
| 2020 | $ - | $ 3.3 | $ 2.3 | $ 4.7 | $ 7.8 | $ 5.6 | $ 5.0 | $ 0.5 | $ 0.4 | $ 29.5 |
| 2021 | $ - | $ 3.4 | $ 2.3 | $ 4.8 | $ 7.9 | $ 5.6 | $ 5.1 | $ 0.5 | $ 0.4 | $ 29.9 |
| 2022 | $ - | $ 3.4 | $ 2.3 | $ 4.9 | $ 8.0 | $ 5.7 | $ 5.1 | $ 0.5 | $ 0.4 | $ 30.4 |
| 2023 | $ - | $ 3.5 | $ 2.4 | $ 5.0 | $ 8.1 | $ 5.8 | $ 5.2 | $ 0.5 | $ 0.4 | $ 30.8 |
| 2024 | $ - | $ 3.5 | $ 2.4 | $ 5.0 | $ 8.2 | $ 5.9 | $ 5.2 | $ 0.5 | $ 0.4 | $ 31.2 |
| 2025 | $ - | $ 3.6 | $ 2.4 | $ 5.1 | $ 8.3 | $ 6.0 | $ 5.3 | $ 0.5 | $ 0.4 | $ 31.6 |
| 2026 | $ - | $ 3.7 | $ 2.5 | $ 5.2 | $ 8.5 | $ 6.1 | $ 5.3 | $ 0.5 | $ 0.4 | $ 32.1 |
| 2027 | $ - | $ 3.7 | $ 2.5 | $ 5.3 | $ 8.6 | $ 6.2 | $ 5.4 | $ 0.5 | $ 0.4 | $ 32.5 |
| 2028 | $ - | $ 3.8 | $ 2.5 | $ 5.3 | $ 8.7 | $ 6.3 | $ 5.4 | $ 0.5 | $ 0.4 | $ 32.9 |
| 2029 | $ - | $ 3.8 | $ 2.6 | $ 5.4 | $ 8.8 | $ 6.3 | $ 5.5 | $ 0.5 | $ 0.4 | $ 33.4 |
| 2030 | $ - | $ 3.9 | $ 2.6 | $ 5.5 | $ 8.9 | $ 6.4 | $ 5.5 | $ 0.5 | $ 0.4 | $ 33.8 |
| 2031 | $ - | $ 3.9 | $ 2.7 | $ 5.5 | $ 9.0 | $ 6.5 | $ 5.6 | $ 0.5 | $ 0.4 | $ 34.2 |
| 2032 | $ - | $ 4.0 | $ 2.7 | $ 5.6 | $ 9.1 | $ 6.6 | $ 5.6 | $ 0.5 | $ 0.4 | $ 34.6 |
| 2033 | $ - | $ 4.1 | $ 2.7 | $ 5.7 | $ 9.3 | $ 6.7 | $ 5.7 | $ 0.5 | $ 0.4 | $ 35.1 |
| 2034 | $ - | $ 4.1 | $ 2.8 | $ 5.8 | $ 9.4 | $ 6.8 | $ 5.7 | $ 0.5 | $ 0.4 | $ 35.5 |
| 2035 | $ - | $ 4.2 | $ 2.8 | $ 5.8 | $ 9.5 | $ 6.9 | $ 5.8 | $ 0.6 | $ 0.4 | $ 35.9 |
| 2036 | $ - | $ 4.2 | $ 2.8 | $ 5.9 | $ 9.6 | $ 7.0 | $ 5.8 | $ 0.6 | $ 0.5 | $ 36.3 |
| 30 Yr NPV at 3% | $ - | $ 47.8 | $ 32.6 | $ 69.3 | $ 113.5 | $ 84.2 | $ 75.0 | $ 7.0 | $ 4.8 | $ 434.2 |
| 30 YR NPV at 7% | $ - | $ 23.4 | $ 16.0 | $ 34.5 | $ 56.5 | $ 42.7 | $ 38.4 | $ 3.6 | $ 2.3 | $ 217.4 |

Table 8.3-4
Aggregate Equipment Variable Costs by Pollutant
($Millions of 2002 dollars)

| Year | PM Costs | NOx Costs | Total Variable Costs |
|---|---|---|---|
| 2008 | $ - | $ - | $ - |
| 2009 | $ - | $ - | $ - |
| 2010 | $ - | $ - | $ - |
| 2011 | $ 6.8 | $ 2.3 | $ 9.1 |
| 2012 | $ 14.7 | $ 4.9 | $ 19.6 |
| 2013 | $ 19.7 | $ 4.5 | $ 24.2 |
| 2014 | $ 17.1 | $ 10.8 | $ 27.9 |
| 2015 | $ 16.5 | $ 11.0 | $ 27.5 |
| 2016 | $ 16.8 | $ 11.1 | $ 27.9 |
| 2017 | $ 17.0 | $ 11.3 | $ 28.2 |
| 2018 | $ 17.2 | $ 11.4 | $ 28.7 |
| 2019 | $ 17.5 | $ 11.6 | $ 29.1 |
| 2020 | $ 17.7 | $ 11.8 | $ 29.5 |
| 2021 | $ 18.0 | $ 11.9 | $ 29.9 |
| 2022 | $ 18.3 | $ 12.1 | $ 30.4 |
| 2023 | $ 18.5 | $ 12.3 | $ 30.8 |
| 2024 | $ 18.8 | $ 12.4 | $ 31.2 |
| 2025 | $ 19.0 | $ 12.6 | $ 31.6 |
| 2026 | $ 19.3 | $ 12.8 | $ 32.1 |
| 2027 | $ 19.6 | $ 12.9 | $ 32.5 |
| 2028 | $ 19.8 | $ 13.1 | $ 32.9 |
| 2029 | $ 20.1 | $ 13.3 | $ 33.4 |
| 2030 | $ 20.4 | $ 13.4 | $ 33.8 |
| 2031 | $ 20.6 | $ 13.6 | $ 34.2 |
| 2032 | $ 20.9 | $ 13.8 | $ 34.6 |
| 2033 | $ 21.1 | $ 13.9 | $ 35.1 |
| 2034 | $ 21.4 | $ 14.1 | $ 35.5 |
| 2035 | $ 21.7 | $ 14.3 | $ 35.9 |
| 2036 | $ 21.9 | $ 14.4 | $ 36.3 |
| 30 Yr NPV at 3% | $ 268.9 | $ 165.3 | $ 434.2 |
| 30 Yr NPV at 7% | $ 136.3 | $ 81.1 | $ 217.4 |

## 8.4 Aggregate Fuel Costs and Other Operating Costs

Aggregate costs presented here are used in the calculation of costs per ton of emission reductions resulting from this final rule. This includes a two-step fuel sulfur control program consisting of a NRLM sulfur cap of 500 ppm beginning in 2007 to be followed by a nonroad (NR) sulfur cap of 15 ppm beginning in 2010 and a locomotive and marine (L&M) sulfur cap of 15 ppm beginning in 2012. Refer to Chapters 5 and 7 for more information about the fuel program and how the costs for that portion of the NRT4 final rule were estimated.

As noted, the second step in the fuel program limits NR sulfur levels to 15 ppm beginning in 2010. This fuel program enables the introduction of advanced emission-control technologies—CDPFs and NOx adsorbers—that will enable nonroad engines to meet the new Tier 4 standards, and it also achieves additional emissions reductions from the fuel control itself (i.e., independent of new engine standards). The combination of the two-step NRLM fuel program and the new diesel engine standards represents the full engine and fuel program (i.e., the NRT4 final rule). Section 8.4.1 presents our estimate of the aggregate fuel costs associated with the NRT4 final rule. Sections 8.4-2 through 8.4-4 present estimates of other operating costs—CDPF and CCV maintenance, fuel economy impacts, and oil change maintenance—associated with the NRT4 final rule. Section 8.4-5 presents the cost of the fuel program absent any new engine standards. These costs differ from the costs associated with the fuel program costs of the NRT4 final rule in that no CDPF and CCV maintenance costs, and no fuel economy impacts would be realized. We present these costs because they are used in calculations of $/ton associated with such a "fuel-only" scenario.

### 8.4.1 Aggregate Fuel Costs

Fuel costs, described in detail in Chapter 7, are developed on a cent-per-gallon basis. Table 8.4-1 summarizes cent-per-gallon fuel costs (see Table 7.5-1), estimated fuel volumes for NR, L&M, and the resultant annual fuel costs associated with the two-step NRT4 final rule fuel program. Table 8.4-1 shows that the 30-year net present value of the new lower sulfur requirements is estimated at $16.3 billion. This assumes a three percent social discount rate. Note that the affected fuel volumes presented in Table 8.4-1 are gallons consumed in both new and existing engines since both new and existing engines will have to pay for the higher cost fuel. We have not included spillover gallons or other such gallons that would have entered the NRLM fuel pool with a sulfur level below the new cap absent the new requirements since these gallons do not represent an incremental increase in costs associated with the NRT4 final rule.

Table 8.4-1
Aggregate Fuel Costs of the Two-Step Fuel Program ($2002)

| Year | Affected NR | | Affected L&M | | Fuel Cost* | | NR Fuel Costs | | | L&M Fuel Costs | | | NRLM Annual Fuel Costs ($10^6$ dollars) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | 500 ppm ($/gal) | 15 ppm ($/gal) | 500 ppm ($10^6$ dollars) | 15 ppm ($10^6$ dollars) | Total ($10^6$ dollars) | 500 ppm ($10^6$ dollars) | 15 ppm ($10^6$ dollars) | Total ($10^6$ dollars) | |
| 2007 | 4,790 | - | 1,990 | - | $ 0.021 | $ - | $ 101 | - | $ 101 | $ 42 | $ - | $ 42 | $ 142 |
| 2008 | 8,406 | - | 3,454 | - | $ 0.021 | $ - | $ 177 | - | $ 177 | $ 73 | $ - | $ 73 | $ 249 |
| 2009 | 8,599 | - | 3,498 | - | $ 0.021 | $ - | $ 181 | - | $ 181 | $ 73 | $ - | $ 73 | $ 254 |
| 2010 | 4,014 | 6,189 | 3,185 | 0 | $ 0.028 | $ 0.058 | $ 112 | 359 | $ 471 | $ 89 | $ 0 | $ 89 | $ 561 |
| 2011 | 614 | 8,145 | 2,975 | 0 | $ 0.033 | $ 0.058 | $ 20 | 472 | $ 493 | $ 98 | $ 0 | $ 98 | $ 591 |
| 2012 | 528 | 8,420 | 1,396 | 1,965 | $ 0.034 | $ 0.062 | $ 18 | 518 | $ 536 | $ 48 | $ 121 | $ 169 | $ 704 |
| 2013 | 468 | 8,671 | 247 | 3,397 | $ 0.035 | $ 0.064 | $ 16 | 555 | $ 571 | $ 9 | $ 217 | $ 226 | $ 797 |
| 2014 | 199 | 9,713 | 104 | 3,081 | $ 0.035 | $ 0.068 | $ 7 | 656 | $ 663 | $ 4 | $ 208 | $ 212 | $ 874 |
| 2015 | - | 10,539 | - | 2,860 | | $ 0.070 | $ - | 738 | $ 738 | $ - | $ 200 | $ 200 | $ 938 |
| 2016 | - | 10,747 | - | 2,888 | | $ 0.070 | $ - | 752 | $ 752 | $ - | $ 202 | $ 202 | $ 954 |
| 2017 | - | 10,955 | - | 2,918 | | $ 0.070 | $ - | 767 | $ 767 | $ - | $ 204 | $ 204 | $ 971 |
| 2018 | - | 11,162 | - | 2,953 | | $ 0.070 | $ - | 781 | $ 781 | $ - | $ 207 | $ 207 | $ 988 |
| 2019 | - | 11,370 | - | 2,995 | | $ 0.070 | $ - | 796 | $ 796 | $ - | $ 210 | $ 210 | $ 1,006 |
| 2020 | - | 11,578 | - | 3,024 | | $ 0.070 | $ - | 810 | $ 810 | $ - | $ 212 | $ 212 | $ 1,022 |
| 2021 | - | 11,786 | - | 3,052 | | $ 0.070 | $ - | 825 | $ 825 | $ - | $ 214 | $ 214 | $ 1,039 |
| 2022 | - | 11,994 | - | 3,093 | | $ 0.070 | $ - | 840 | $ 840 | $ - | $ 217 | $ 217 | $ 1,056 |
| 2023 | - | 12,201 | - | 3,125 | | $ 0.070 | $ - | 854 | $ 854 | $ - | $ 219 | $ 219 | $ 1,073 |
| 2024 | - | 12,409 | - | 3,161 | | $ 0.070 | $ - | 869 | $ 869 | $ - | $ 221 | $ 221 | $ 1,090 |
| 2025 | - | 12,617 | - | 3,195 | | $ 0.070 | $ - | 883 | $ 883 | $ - | $ 224 | $ 224 | $ 1,107 |
| 2026 | - | 12,823 | - | 3,230 | | $ 0.070 | $ - | 898 | $ 898 | $ - | $ 226 | $ 226 | $ 1,124 |
| 2027 | - | 13,030 | - | 3,265 | | $ 0.070 | $ - | 912 | $ 912 | $ - | $ 229 | $ 229 | $ 1,141 |
| 2028 | - | 13,236 | - | 3,301 | | $ 0.070 | $ - | 927 | $ 927 | $ - | $ 231 | $ 231 | $ 1,158 |
| 2029 | - | 13,442 | - | 3,336 | | $ 0.070 | $ - | 941 | $ 941 | $ - | $ 233 | $ 233 | $ 1,174 |
| 2030 | - | 13,649 | - | 3,371 | | $ 0.070 | $ - | 955 | $ 955 | $ - | $ 236 | $ 236 | $ 1,191 |
| 2031 | - | 13,855 | - | 3,406 | | $ 0.070 | $ - | 970 | $ 970 | $ - | $ 238 | $ 238 | $ 1,208 |
| 2032 | - | 14,061 | - | 3,441 | | $ 0.070 | $ - | 984 | $ 984 | $ - | $ 241 | $ 241 | $ 1,225 |
| 2033 | - | 14,268 | - | 3,476 | | $ 0.070 | $ - | 999 | $ 999 | $ - | $ 243 | $ 243 | $ 1,242 |
| 2034 | - | 14,474 | - | 3,512 | | $ 0.070 | $ - | 1,013 | $ 1,013 | $ - | $ 246 | $ 246 | $ 1,259 |
| 2035 | - | 14,680 | - | 3,547 | | $ 0.070 | $ - | 1,028 | $ 1,028 | $ - | $ 248 | $ 248 | $ 1,276 |
| 2036 | - | 14,887 | - | 3,582 | | $ 0.070 | $ - | 1,042 | $ 1,042 | $ - | $ 251 | $ 251 | $ 1,293 |
| 30 Yr NPV at 3% | 24,054 | 180,224 | 14,363 | 44,087 | | | $ 547 | $ 12,360 | $ 12,907 | $ 368 | $ 3,052 | $ 3,419 | $ 16,326 |
| 30 Yr NPV at 7% | 20,174 | 92,196 | 11,729 | 22,124 | | | $ 456 | $ 6,261 | $ 6,717 | $ 297 | $ 1,524 | $ 1,821 | $ 8,538 |

* Fuel costs are relative to uncontrolled fuel and assume that, during the transitional years of 2010, 2012, & 2014, the first 5 months are at the previous year's cost and the remaining 7 months are at the next year's cost.
See Appendix 8B for how these fuel volumes were developed.

### 8.4.2 Aggregate Oil-Change Maintenance Savings

Maintenance savings associated with extended oil-change intervals are developed on a cent-per-gallon basis, as described in Section 6.2.3.1. The cent-per-gallon savings for nonroad engines is the fleet weighted value for nonroad engines presented in Section 6.2.3.1. This fleet weighted value is derived using data presented in Table 6.2-28 as discussed in that section. The cent-per-gallon savings for locomotive and marine engines is taken directly from Table 6.2-28. Table 8.4-2 summarizes the annual maintenance savings and associated fuel volumes for nonroad, locomotive, and marine engines. Note that the fuel volumes used for oil change maintenance savings are the same affected volumes presented in Table 8.4-1. We have not included savings associated with unaffected gallons (i.e., low sulfur gallons that would have entered the NRLM fuel pool absent the new requirements) since we assume that engines consuming those gallons benefit from the low sulfur fuel absent the NRT4 final rule. As shown in Table 8.4-2, the net present value of the oil change maintenance savings is estimated at $7.1 billion. This assumes a three percent social discount rate.

Table 8.4-2
Oil-Change Maintenance Savings Associated with the Two-Step Fuel Program ($2002)

| Year | Affected NR | | Affected L&M | | NR Savings | | L&M Savings | | NRLM |
|---|---|---|---|---|---|---|---|---|---|
| | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | savings=$0.029/gal ($10^6$ dollars) | savings=$0.032/gal ($10^6$ dollars) | savings=$0.010/gal ($10^6$ dollars) | savings=$0.011/gal ($10^6$ dollars) | Total Savings ($10^6$ dollars) |
| 2007 | 4,790 | - | 1,990 | - | $ 140 | $ - | $ 21 | $ - | $ 161 |
| 2008 | 8,406 | - | 3,454 | - | $ 246 | $ - | $ 36 | $ - | $ 282 |
| 2009 | 8,599 | - | 3,498 | - | $ 251 | $ - | $ 37 | $ - | $ 288 |
| 2010 | 4,014 | 6,189 | 3,185 | 0 | $ 117 | $ 198 | $ 33 | $ 0 | $ 349 |
| 2011 | 614 | 8,145 | 2,975 | 0 | $ 18 | $ 261 | $ 31 | $ 0 | $ 310 |
| 2012 | 528 | 8,420 | 1,396 | 1,965 | $ 15 | $ 270 | $ 15 | $ 23 | $ 322 |
| 2013 | 468 | 8,671 | 247 | 3,397 | $ 14 | $ 278 | $ 3 | $ 39 | $ 333 |
| 2014 | 199 | 9,713 | 104 | 3,081 | $ 6 | $ 311 | $ 1 | $ 35 | $ 353 |
| 2015 | - | 10,539 | - | 2,860 | $ - | $ 338 | $ - | $ 33 | $ 370 |
| 2016 | - | 10,747 | - | 2,888 | $ - | $ 344 | $ - | $ 33 | $ 377 |
| 2017 | - | 10,955 | - | 2,918 | $ - | $ 351 | $ - | $ 33 | $ 384 |
| 2018 | - | 11,162 | - | 2,953 | $ - | $ 358 | $ - | $ 34 | $ 391 |
| 2019 | - | 11,370 | - | 2,995 | $ - | $ 364 | $ - | $ 34 | $ 399 |
| 2020 | - | 11,578 | - | 3,024 | $ - | $ 371 | $ - | $ 35 | $ 406 |
| 2021 | - | 11,786 | - | 3,052 | $ - | $ 377 | $ - | $ 35 | $ 412 |
| 2022 | - | 11,994 | - | 3,093 | $ - | $ 384 | $ - | $ 35 | $ 420 |
| 2023 | - | 12,201 | - | 3,125 | $ - | $ 391 | $ - | $ 36 | $ 427 |
| 2024 | - | 12,409 | - | 3,161 | $ - | $ 397 | $ - | $ 36 | $ 434 |
| 2025 | - | 12,617 | - | 3,195 | $ - | $ 404 | $ - | $ 37 | $ 441 |
| 2026 | - | 12,823 | - | 3,230 | $ - | $ 411 | $ - | $ 37 | $ 448 |
| 2027 | - | 13,030 | - | 3,265 | $ - | $ 417 | $ - | $ 37 | $ 455 |
| 2028 | - | 13,236 | - | 3,301 | $ - | $ 424 | $ - | $ 38 | $ 462 |
| 2029 | - | 13,442 | - | 3,336 | $ - | $ 431 | $ - | $ 38 | $ 469 |
| 2030 | - | 13,649 | - | 3,371 | $ - | $ 437 | $ - | $ 39 | $ 476 |
| 2031 | - | 13,855 | - | 3,406 | $ - | $ 444 | $ - | $ 39 | $ 483 |
| 2032 | - | 14,061 | - | 3,441 | $ - | $ 450 | $ - | $ 39 | $ 490 |
| 2033 | - | 14,268 | - | 3,476 | $ - | $ 457 | $ - | $ 40 | $ 497 |
| 2034 | - | 14,474 | - | 3,512 | $ - | $ 464 | $ - | $ 40 | $ 504 |
| 2035 | - | 14,680 | - | 3,547 | $ - | $ 470 | $ - | $ 41 | $ 511 |
| 2036 | - | 14,887 | - | 3,582 | $ - | $ 477 | $ - | $ 41 | $ 518 |
| 30 Yr NPV at 3% | 24,054 | 180,224 | 14,363 | 44,087 | $ 703 | $ 5,772 | $ 150 | $ 506 | $ 7,132 |
| 30 Yr NPV at 7% | 20,174 | 92,196 | 11,729 | 22,124 | $ 590 | $ 2,953 | $ 123 | $ 254 | $ 3,919 |

### 8.4.3 Aggregate CDPF Maintenance, CDPF Regeneration, and CCV Maintenance Costs

Costs associated with CDPF maintenance and CCV maintenance are developed on a cent-per-gallon basis as described in Section 6.2.3. Table 8.4-3 summarizes the CDPF maintenance and CDPF regeneration costs associated with the NRT4 fuel program. The fuel volumes shown in Table 8.4-3 differ from those shown in Tables 8.4-1 through 8.4-2 because here we want only those gallons consumed in new CDPF equipped engines. Therefore, fuel consumed in existing engines and fuel consumed in new engines not yet equipped with a CDPF are not included in Table 8.4-3.

The cent-per-gallon costs shown for CDPF maintenance are taken from data presented in Table 6.2-29. As engines in different power categories add CDPFs, the weighted $/gallon number changes until all new engines have added a CDPF and the fleet weighted average becomes the 0.6 cents/gallon value presented in Section 6.2.3.2. The cent-per-gallon costs shown for CDPF regeneration are taken from information presented in Section 6.2.3.3.2. The weighted value shown accounts for the 60 cent/gallon base fuel cost for diesel fuel and the NOx phase-in on different engines—engines equipped with a CDPF and no NOx adsorber incur a 2% fuel economy impact associated with regeneration while engines equipped with both a CDPF and a NOx adsorber incur a 1% fuel economy impact. This weighted number also accounts for the different 15 ppm fuel cost during the years 2010-2014 and then for 2015 and later.

As shown in Table 8.4-3, the 30-year net present value of these two CDPF-related operating costs is estimated at $2.3 billion. This assumes a three percent social discount rate.

Table 8.4-3
CDPF Maintenance and CDPF Regeneration Costs Associated with the Two-Step Fuel Program ($2002)

| Year | Fuel Consumed in New CDPF Equipped Engines ($10^6$ gallons) | Weighted Maintenance Cost ($/gal) | Weighted Regeneration Cost ($/gal) | CDPF Maintenance Cost ($10^6$ dollars) | CDPF Regeneration Cost ($10^6$ dollars) | Total Costs ($10^6$ dollars) |
|---|---|---|---|---|---|---|
| 2007 | - | $ - | $ - | $ - | $ - | $ - |
| 2008 | - | $ - | $ - | $ - | $ - | $ - |
| 2009 | - | $ - | $ - | $ - | $ - | $ - |
| 2010 | - | $ - | $ - | $ - | $ - | $ - |
| 2011 | 559 | $ 0.002 | $ 0.010 | $ 1 | $ 6 | $ 6 |
| 2012 | 1,543 | $ 0.003 | $ 0.010 | $ 5 | $ 15 | $ 20 |
| 2013 | 2,774 | $ 0.005 | $ 0.010 | $ 14 | $ 28 | $ 42 |
| 2014 | 4,010 | $ 0.006 | $ 0.007 | $ 23 | $ 30 | $ 53 |
| 2015 | 5,343 | $ 0.006 | $ 0.008 | $ 31 | $ 41 | $ 73 |
| 2016 | 6,630 | $ 0.006 | $ 0.008 | $ 40 | $ 52 | $ 92 |
| 2017 | 7,842 | $ 0.006 | $ 0.008 | $ 47 | $ 62 | $ 110 |
| 2018 | 8,966 | $ 0.006 | $ 0.008 | $ 55 | $ 72 | $ 127 |
| 2019 | 10,006 | $ 0.006 | $ 0.008 | $ 61 | $ 81 | $ 142 |
| 2020 | 10,975 | $ 0.006 | $ 0.008 | $ 67 | $ 89 | $ 156 |
| 2021 | 11,848 | $ 0.006 | $ 0.008 | $ 72 | $ 97 | $ 169 |
| 2022 | 12,631 | $ 0.006 | $ 0.008 | $ 77 | $ 103 | $ 180 |
| 2023 | 13,358 | $ 0.006 | $ 0.008 | $ 82 | $ 109 | $ 191 |
| 2024 | 14,044 | $ 0.006 | $ 0.008 | $ 86 | $ 114 | $ 200 |
| 2025 | 14,697 | $ 0.006 | $ 0.008 | $ 90 | $ 120 | $ 210 |
| 2026 | 15,304 | $ 0.006 | $ 0.008 | $ 94 | $ 125 | $ 218 |
| 2027 | 15,852 | $ 0.006 | $ 0.008 | $ 97 | $ 129 | $ 226 |
| 2028 | 16,351 | $ 0.006 | $ 0.008 | $ 100 | $ 133 | $ 234 |
| 2029 | 16,825 | $ 0.006 | $ 0.008 | $ 103 | $ 137 | $ 240 |
| 2030 | 17,277 | $ 0.006 | $ 0.008 | $ 106 | $ 141 | $ 247 |
| 2031 | 17,704 | $ 0.006 | $ 0.008 | $ 109 | $ 144 | $ 253 |
| 2032 | 18,116 | $ 0.006 | $ 0.008 | $ 111 | $ 148 | $ 259 |
| 2033 | 18,521 | $ 0.006 | $ 0.008 | $ 113 | $ 151 | $ 264 |
| 2034 | 18,913 | $ 0.006 | $ 0.008 | $ 116 | $ 154 | $ 270 |
| 2035 | 19,287 | $ 0.006 | $ 0.008 | $ 118 | $ 157 | $ 275 |
| 2036 | 19,645 | $ 0.006 | $ 0.008 | $ 120 | $ 160 | $ 280 |
| 30 Yr NPV at 3% | 164,697 | | | $ 997 | $ 1,343 | $ 2,340 |
| 30 Yr NPV at 7% | 74,092 | | | $ 445 | $ 605 | $ 1,050 |

* Note that fuel used in CDPF engines includes some highway spillover fuel.
**Weighted Regeneration Cost ($/gal) changes year-to-year due to different fuel economy impacts with a NOx adsorber (1 percent) and without a NOx adsorber (2 percent) matched with the phase-in schedules of the emission standards.

The cent-per-gallon costs for CCV maintenance are taken from data presented in Table 6.2-30. Table 8.4-4 presents the annual costs associated with CCV maintenance. The gallons shown in Table 8.4-4 are gallons of fuel consumed in engines in power ranges for which the new CCV requirements have gone into effect. However, these are not necessarily equal to the gallons consumed in new CCV equipped engines since only the turbocharged engines will be adding a CCV system. Therefore, the cent-per-gallon costs in early years is essentially zero since so few engines in the <75hp range are turbocharged and, hence, so few are adding a CCV system and incurring the associated maintenance costs. As shown in Table 8.4-4, the 30-year net present value of the CCV maintenance costs are estimated at $275 million. This assumes a three percent social discount rate.

Table 8.4-4
CCV Maintenance Costs Associated with the Two-Step Fuel Program
($2002)

| Year | Fuel Consumed in Power Categories Adding CCV System ($10^6$ gallons) | Weighted Maintenance Cost ($/gal) | Total Costs ($10^6$ dollars) |
|---|---|---|---|
| 2007 | - | $ - | $ - |
| 2008 | 242 | $ 0.000 | $ 0 |
| 2009 | 248 | $ 0.000 | $ 0 |
| 2010 | 254 | $ 0.000 | $ 0 |
| 2011 | 927 | $ 0.001 | $ 1 |
| 2012 | 2,023 | $ 0.001 | $ 3 |
| 2013 | 3,369 | $ 0.002 | $ 5 |
| 2014 | 4,716 | $ 0.002 | $ 7 |
| 2015 | 6,160 | $ 0.002 | $ 9 |
| 2016 | 7,552 | $ 0.002 | $ 11 |
| 2017 | 8,857 | $ 0.002 | $ 13 |
| 2018 | 10,042 | $ 0.002 | $ 15 |
| 2019 | 11,139 | $ 0.002 | $ 17 |
| 2020 | 12,161 | $ 0.002 | $ 18 |
| 2021 | 13,084 | $ 0.002 | $ 20 |
| 2022 | 13,913 | $ 0.002 | $ 21 |
| 2023 | 14,680 | $ 0.002 | $ 22 |
| 2024 | 15,402 | $ 0.002 | $ 23 |
| 2025 | 16,088 | $ 0.002 | $ 24 |
| 2026 | 16,724 | $ 0.002 | $ 25 |
| 2027 | 17,301 | $ 0.002 | $ 26 |
| 2028 | 17,827 | $ 0.002 | $ 27 |
| 2029 | 18,327 | $ 0.002 | $ 28 |
| 2030 | 18,805 | $ 0.002 | $ 28 |
| 2031 | 19,258 | $ 0.002 | $ 29 |
| 2032 | 19,695 | $ 0.002 | $ 30 |
| 2033 | 20,125 | $ 0.002 | $ 30 |
| 2034 | 20,543 | $ 0.002 | $ 31 |
| 2035 | 20,940 | $ 0.002 | $ 32 |
| 2036 | 21,323 | $ 0.002 | $ 32 |
| 30 Yr NPV at 3% | 182,540 | | $ 275 |
| 30 Yr NPV at 7% | 82,865 | | $ 124 |

* Weighted Maintenance Cost ($/gal) changes year-to-year due to the implementation schedule for engines adding the CCV system.

### 8.4.4 Summary of Aggregate Operating Costs

The net operating costs include the incremental costs for fuel (Table 8.4-1), cost savings from reduced oil changes (Table 8.4-2), costs for CDPF maintenance and regeneration (Table 8.4-3), and costs for CCV maintenance (Table 8.4-4). The results of this summation for the two-step NRT4 program are shown in Table 8.4-5. The oil-change maintenance savings, CDPF maintenance and regeneration costs, and the CCV maintenance costs are added together in Table 8.4-5 and presented as “Other Operating Costs.” The other operating costs are presented as negative values because the oil change maintenance savings (negative costs) outweigh the other operating costs and, thus, their summation represents a net savings. The "Net Operating Cost" is the sum of the incremental fuel costs shown in Table 8.4-1 and the other operating costs shown in Tables 8.4-2 through 8.4-4. As shown in Table 8.4-5, the 30-year net present value of the net operating costs is estimated at $11.8 billion consisting of the $16.3 billion fuel cost and the $4.5 billion savings associated with other operating costs. These net present values assume a three percent social discount rate.

Also included in Table 8.4-5 are the costs by 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.

Table 8.4-5
Aggregate Net Operating Costs and Costs by Pollutant
Associated with the NRT4 Program
($2002)

| Year | Fuel Costs ($10^6$ dollars) | Other Operating Costs ($10^6$ dollars) | Net Operating Costs ($10^6$ dollars) | SOx Related Costs ($10^6$ dollars) | PM Related Costs ($10^6$ dollars) | NOx+HC Related Costs ($10^6$ dollars) |
|---|---|---|---|---|---|---|
| 2007 | $ 142 | $ (161) | $ (18) | $ (12) | $ (6) | $ - |
| 2008 | $ 249 | $ (282) | $ (33) | $ (22) | $ (11) | $ 0 |
| 2009 | $ 254 | $ (288) | $ (34) | $ (23) | $ (11) | $ 0 |
| 2010 | $ 561 | $ (349) | $ 212 | $ 88 | $ 84 | $ 40 |
| 2011 | $ 591 | $ (302) | $ 289 | $ 117 | $ 118 | $ 54 |
| 2012 | $ 704 | $ (299) | $ 406 | $ 172 | $ 170 | $ 64 |
| 2013 | $ 797 | $ (286) | $ 512 | $ 217 | $ 223 | $ 72 |
| 2014 | $ 874 | $ (294) | $ 581 | $ 232 | $ 259 | $ 90 |
| 2015 | $ 938 | $ (288) | $ 650 | $ 245 | $ 300 | $ 105 |
| 2016 | $ 954 | $ (274) | $ 680 | $ 249 | $ 324 | $ 108 |
| 2017 | $ 971 | $ (261) | $ 710 | $ 253 | $ 347 | $ 111 |
| 2018 | $ 988 | $ (250) | $ 738 | $ 257 | $ 368 | $ 114 |
| 2019 | $ 1,006 | $ (240) | $ 766 | $ 261 | $ 389 | $ 116 |
| 2020 | $ 1,022 | $ (231) | $ 791 | $ 265 | $ 408 | $ 119 |
| 2021 | $ 1,039 | $ (224) | $ 815 | $ 268 | $ 425 | $ 122 |
| 2022 | $ 1,056 | $ (219) | $ 838 | $ 272 | $ 441 | $ 124 |
| 2023 | $ 1,073 | $ (214) | $ 859 | $ 276 | $ 456 | $ 127 |
| 2024 | $ 1,090 | $ (210) | $ 880 | $ 280 | $ 470 | $ 129 |
| 2025 | $ 1,107 | $ (207) | $ 900 | $ 284 | $ 484 | $ 132 |
| 2026 | $ 1,124 | $ (204) | $ 920 | $ 288 | $ 497 | $ 134 |
| 2027 | $ 1,141 | $ (202) | $ 938 | $ 292 | $ 509 | $ 137 |
| 2028 | $ 1,158 | $ (201) | $ 956 | $ 296 | $ 521 | $ 139 |
| 2029 | $ 1,174 | $ (201) | $ 974 | $ 300 | $ 532 | $ 141 |
| 2030 | $ 1,191 | $ (201) | $ 991 | $ 304 | $ 543 | $ 144 |
| 2031 | $ 1,208 | $ (201) | $ 1,007 | $ 308 | $ 553 | $ 146 |
| 2032 | $ 1,225 | $ (201) | $ 1,024 | $ 312 | $ 563 | $ 148 |
| 2033 | $ 1,242 | $ (202) | $ 1,040 | $ 316 | $ 573 | $ 151 |
| 2034 | $ 1,259 | $ (203) | $ 1,056 | $ 320 | $ 583 | $ 153 |
| 2035 | $ 1,276 | $ (204) | $ 1,072 | $ 324 | $ 593 | $ 155 |
| 2036 | $ 1,293 | $ (205) | $ 1,088 | $ 328 | $ 602 | $ 157 |
| 30 Yr NPV at 3% | $ 16,326 | $ (4,517) | $ 11,809 | $ 3,934 | $ 6,091 | $ 1,784 |
| 30 Yr NPV at 7% | $ 8,538 | $ (2,745) | $ 5,793 | $ 1,976 | $ 2,928 | $ 889 |

### 8.4.5 Summary of Aggregate Operating Costs Associated with a Fuel-only Scenario

The aggregate operating costs of a fuel-only scenario would be essentially the same as those presented above for the full NRT4 program with the exception of those operating costs associated with maintenance or regeneration of new engine hardware. These operating cost elements would not be incurred because without new engine standards the new engine hardware would not be added. However, the oil change maintenance savings would still be realized just as they would under the full NRT4 program.

As noted several times throughout this chapter, Table 8.1-2 shows how we allocated costs to each pollutant under the full engine and fuel program. However, the allocations shown in that table assume an engine program to which a portion of the fuel-related costs are allocated. Specifically, the 15 ppm NR fuel, which enables aftertreatment devices and, thus, new NR engine standards, is split evenly between engine derived benefits and fuel derived benefits. Subsequently, the costs allocated to fuel derived benefits were split one-third to PM and two-thirds to SOx.

Under the fuel-only scenario, there are no new engine standards. As a result, all the fuel costs are allocated to fuel-derived benefits. Consistent with the approach taken in the full engine and fuel program, we have allocated one-third of those costs to PM and two-thirds of those costs to SOx. Table 8.4-6 shows the cost allocations under the fuel-only scenario.

Table 8.4-6
Cost Allocations under the Fuel-only Scenario

<table>
<tr><th>Item</th><th></th><th>NOx+HC</th><th>PM</th><th>SOx</th></tr>
<tr><td rowspan="3">Fuel Costs – incremental cent/gallon</td><td>500 ppm Affected NRLM</td><td rowspan="6"></td><td rowspan="6">33%</td><td rowspan="6">67%</td></tr>
<tr><td>15 ppm Affected NR</td></tr>
<tr><td>15 ppm Affected L&M</td></tr>
<tr><td rowspan="3">Operating Costs – Oil-Change Savings</td><td>500 ppm Affected NRLM</td></tr>
<tr><td>15 ppm Affected NR</td></tr>
<tr><td>15 ppm Affected L&M</td></tr>
<tr><td>Operating Costs – CDPF Maintenance</td><td rowspan="3" colspan="4">None</td></tr>
<tr><td>Operating Costs – CDPF Regen (FE impact)</td></tr>
<tr><td>Operating Costs – CCV Maintenance</td></tr>
</table>

Note that there are no costs associated with CDPF and CCV maintenance or with CDPF regeneration since there would be no new engine standards under the fuel-only scenario. Note also that the oil change maintenance savings would still be realized absent any new engine standards.

Table 8.4-7 presents the net operating costs associated with a fuel-only scenario. The costs presented in Table 8.4-7 include the incremental costs for fuel (Table 8.4-1) and costs for oil-change maintenance savings (Table 8.4-2). The oil-change maintenance savings are presented in the table as “Other Operating Costs,” and, thus represent a net savings. The “Net Operating

Cost" is the sum of the incremental fuel costs and the other operating costs. Table 8.4-7 also presents these costs by pollutant (refer to Table 8.4-6 for how these costs have been allocated). Since there are no new engine standards under a fuel-only scenario there are no costs associated with technology enablement and, hence, no costs allocated to NOx+NMHC. As shown in Table 8.4-7, the 30-year net present value of costs associated with a fuel-only scenario is estimated at $9.2 billion consisting of the $16.3 billion fuel cost and a $7.1 billion savings associated with oil change maintenance. These values assume a three percent social discount rate.

Table 8.4-7
Aggregate Net Operating Costs and Costs by Pollutant
Associated with a Fuel-Only Scenario
($2002)

| Year | Fuel Costs ($10^6$ dollars) | Other Operating Costs ($10^6$ dollars) | Net Operating Costs ($10^6$ dollars) | SOx Related Costs ($10^6$ dollars) | PM Related Costs ($10^6$ dollars) | NOx+HC Related Costs ($10^6$ dollars) |
|---|---|---|---|---|---|---|
| 2007 | $ 142 | $ (161) | $ (18) | $ (12) | $ (6) | $ - |
| 2008 | $ 249 | $ (282) | $ (33) | $ (22) | $ (11) | $ - |
| 2009 | $ 254 | $ (288) | $ (34) | $ (23) | $ (11) | $ - |
| 2010 | $ 561 | $ (349) | $ 212 | $ 141 | $ 71 | $ - |
| 2011 | $ 591 | $ (310) | $ 281 | $ 187 | $ 94 | $ - |
| 2012 | $ 704 | $ (322) | $ 382 | $ 255 | $ 127 | $ - |
| 2013 | $ 797 | $ (333) | $ 464 | $ 310 | $ 155 | $ - |
| 2014 | $ 874 | $ (353) | $ 521 | $ 347 | $ 174 | $ - |
| 2015 | $ 938 | $ (370) | $ 568 | $ 378 | $ 189 | $ - |
| 2016 | $ 954 | $ (377) | $ 577 | $ 385 | $ 192 | $ - |
| 2017 | $ 971 | $ (384) | $ 587 | $ 391 | $ 196 | $ - |
| 2018 | $ 988 | $ (391) | $ 597 | $ 398 | $ 199 | $ - |
| 2019 | $ 1,006 | $ (399) | $ 607 | $ 405 | $ 202 | $ - |
| 2020 | $ 1,022 | $ (406) | $ 617 | $ 411 | $ 206 | $ - |
| 2021 | $ 1,039 | $ (412) | $ 626 | $ 417 | $ 209 | $ - |
| 2022 | $ 1,056 | $ (420) | $ 636 | $ 424 | $ 212 | $ - |
| 2023 | $ 1,073 | $ (427) | $ 646 | $ 431 | $ 215 | $ - |
| 2024 | $ 1,090 | $ (434) | $ 656 | $ 437 | $ 219 | $ - |
| 2025 | $ 1,107 | $ (441) | $ 666 | $ 444 | $ 222 | $ - |
| 2026 | $ 1,124 | $ (448) | $ 676 | $ 451 | $ 225 | $ - |
| 2027 | $ 1,141 | $ (455) | $ 686 | $ 457 | $ 229 | $ - |
| 2028 | $ 1,158 | $ (462) | $ 696 | $ 464 | $ 232 | $ - |
| 2029 | $ 1,174 | $ (469) | $ 706 | $ 470 | $ 235 | $ - |
| 2030 | $ 1,191 | $ (476) | $ 716 | $ 477 | $ 239 | $ - |
| 2031 | $ 1,208 | $ (483) | $ 725 | $ 484 | $ 242 | $ - |
| 2032 | $ 1,225 | $ (490) | $ 735 | $ 490 | $ 245 | $ - |
| 2033 | $ 1,242 | $ (497) | $ 745 | $ 497 | $ 248 | $ - |
| 2034 | $ 1,259 | $ (504) | $ 755 | $ 503 | $ 252 | $ - |
| 2035 | $ 1,276 | $ (511) | $ 765 | $ 510 | $ 255 | $ - |
| 2036 | $ 1,293 | $ (518) | $ 775 | $ 517 | $ 258 | $ - |
| 30 Yr NPV at 3% | $ 16,326 | $ (7,132) | $ 9,194 | $ 6,130 | $ 3,065 | $ - |
| 30 Yr NPV at 7% | $ 8,538 | $ (3,919) | $ 4,618 | $ 3,079 | $ 1,539 | $ - |

## 8.5 Summary of Aggregate Costs of the Final Rule

Table 8.5-1 presents a summary of all the costs presented above for the NRT4 final rule engine and fuel program. Engine costs are the summation of costs presented in Tables 8.2-1 and 8.2-3, equipment costs are the summation of costs presented in Tables 8.3-1 and 8.3-3, and fuel costs, other operating costs, and net operating costs are presented in Table 8.4-5. The "Total Program Costs" are the summation of engine costs, equipment costs, and net operating costs. As shown, the 30-year net present value of the NRT4 program is estimated at $27.1 billion consisting of $14.1 billion in engine costs, $1.3 billion in equipment costs, $16.3 billion in fuel costs, and a savings of $4.5 billion in other operating costs. These values assume a three percent social discount rate.

Table 8.5-2 presents the summary of all the costs presented above by pollutant (refer to Table 8.1-2 for how we have allocated costs among the various pollutants).

Note that a similar summary of aggregate costs associated with a fuel-only scenario are presented in full in Table 8.4-6 since there are no new engine or equipment costs associated with that scenario.

Table 8.5-1
Summary of Aggregate Costs for the NRT4 Final Engine and Fuel Program
($Millions of 2002 dollars)

| Year | Engine Costs | Equipment Costs | Fuel Costs | Other Operating Costs | Net Operating Costs | Total Annual Costs |
|---|---|---|---|---|---|---|
| 2007 | $ - | $ - | $ 142 | $ (161) | $ (18) | $ (18) |
| 2008 | $ 81 | $ 5 | $ 249 | $ (282) | $ (33) | $ 53 |
| 2009 | $ 82 | $ 5 | $ 254 | $ (288) | $ (34) | $ 53 |
| 2010 | $ 80 | $ 5 | $ 561 | $ (349) | $ 212 | $ 297 |
| 2011 | $ 403 | $ 62 | $ 591 | $ (302) | $ 289 | $ 754 |
| 2012 | $ 718 | $ 106 | $ 704 | $ (299) | $ 406 | $ 1,229 |
| 2013 | $ 882 | $ 121 | $ 797 | $ (286) | $ 512 | $ 1,515 |
| 2014 | $ 973 | $ 146 | $ 874 | $ (294) | $ 581 | $ 1,699 |
| 2015 | $ 950 | $ 149 | $ 938 | $ (288) | $ 650 | $ 1,749 |
| 2016 | $ 920 | $ 150 | $ 954 | $ (274) | $ 680 | $ 1,750 |
| 2017 | $ 910 | $ 150 | $ 971 | $ (261) | $ 710 | $ 1,770 |
| 2018 | $ 901 | $ 146 | $ 988 | $ (250) | $ 738 | $ 1,785 |
| 2019 | $ 890 | $ 147 | $ 1,006 | $ (240) | $ 766 | $ 1,802 |
| 2020 | $ 900 | $ 147 | $ 1,022 | $ (231) | $ 791 | $ 1,838 |
| 2021 | $ 913 | $ 99 | $ 1,039 | $ (224) | $ 815 | $ 1,827 |
| 2022 | $ 927 | $ 66 | $ 1,056 | $ (219) | $ 838 | $ 1,830 |
| 2023 | $ 940 | $ 56 | $ 1,073 | $ (214) | $ 859 | $ 1,855 |
| 2024 | $ 954 | $ 36 | $ 1,090 | $ (210) | $ 880 | $ 1,869 |
| 2025 | $ 967 | $ 32 | $ 1,107 | $ (207) | $ 900 | $ 1,899 |
| 2026 | $ 980 | $ 32 | $ 1,124 | $ (204) | $ 920 | $ 1,932 |
| 2027 | $ 994 | $ 33 | $ 1,141 | $ (202) | $ 938 | $ 1,965 |
| 2028 | $ 1,007 | $ 33 | $ 1,158 | $ (201) | $ 956 | $ 1,997 |
| 2029 | $ 1,021 | $ 33 | $ 1,174 | $ (201) | $ 974 | $ 2,028 |
| 2030 | $ 1,034 | $ 34 | $ 1,191 | $ (201) | $ 991 | $ 2,059 |
| 2031 | $ 1,048 | $ 34 | $ 1,208 | $ (201) | $ 1,007 | $ 2,089 |
| 2032 | $ 1,061 | $ 35 | $ 1,225 | $ (201) | $ 1,024 | $ 2,119 |
| 2033 | $ 1,074 | $ 35 | $ 1,242 | $ (202) | $ 1,040 | $ 2,149 |
| 2034 | $ 1,088 | $ 35 | $ 1,259 | $ (203) | $ 1,056 | $ 2,179 |
| 2035 | $ 1,101 | $ 36 | $ 1,276 | $ (204) | $ 1,072 | $ 2,209 |
| 2036 | $ 1,115 | $ 36 | $ 1,293 | $ (205) | $ 1,088 | $ 2,239 |
| 30 Yr NPV at 3% | $ 14,054 | $ 1,281 | $ 16,326 | $ (4,517) | $ 11,809 | $ 27,144 |
| 30 Yr NPV at 7% | $ 7,215 | $ 754 | $ 8,538 | $ (2,745) | $ 5,793 | $ 13,762 |

Table 8.5-2
Summary of Aggregate Costs for the NRT4 Final Engine and Fuel Program by Pollutant
($Millions of 2002 dollars)

| Year | PM Costs | NOx+NMHC Costs | SOx Costs | Total Costs |
|---|---|---|---|---|
| 2007 | $ (6) | $ - | $ (12) | $ (18) |
| 2008 | $ 74 | $ 0 | $ (22) | $ 53 |
| 2009 | $ 75 | $ 0 | $ (23) | $ 53 |
| 2010 | $ 169 | $ 40 | $ 88 | $ 297 |
| 2011 | $ 458 | $ 179 | $ 117 | $ 754 |
| 2012 | $ 761 | $ 296 | $ 172 | $ 1,229 |
| 2013 | $ 949 | $ 348 | $ 217 | $ 1,515 |
| 2014 | $ 940 | $ 526 | $ 232 | $ 1,699 |
| 2015 | $ 970 | $ 534 | $ 245 | $ 1,749 |
| 2016 | $ 982 | $ 519 | $ 249 | $ 1,750 |
| 2017 | $ 999 | $ 518 | $ 253 | $ 1,770 |
| 2018 | $ 1,004 | $ 524 | $ 257 | $ 1,785 |
| 2019 | $ 1,034 | $ 507 | $ 261 | $ 1,802 |
| 2020 | $ 1,059 | $ 515 | $ 265 | $ 1,838 |
| 2021 | $ 1,061 | $ 497 | $ 268 | $ 1,827 |
| 2022 | $ 1,070 | $ 488 | $ 272 | $ 1,830 |
| 2023 | $ 1,088 | $ 490 | $ 276 | $ 1,855 |
| 2024 | $ 1,112 | $ 477 | $ 280 | $ 1,869 |
| 2025 | $ 1,130 | $ 484 | $ 284 | $ 1,899 |
| 2026 | $ 1,153 | $ 491 | $ 288 | $ 1,932 |
| 2027 | $ 1,174 | $ 498 | $ 292 | $ 1,965 |
| 2028 | $ 1,195 | $ 506 | $ 296 | $ 1,997 |
| 2029 | $ 1,215 | $ 513 | $ 300 | $ 2,028 |
| 2030 | $ 1,235 | $ 520 | $ 304 | $ 2,059 |
| 2031 | $ 1,254 | $ 527 | $ 308 | $ 2,089 |
| 2032 | $ 1,273 | $ 534 | $ 312 | $ 2,119 |
| 2033 | $ 1,292 | $ 541 | $ 316 | $ 2,149 |
| 2034 | $ 1,311 | $ 548 | $ 320 | $ 2,179 |
| 2035 | $ 1,330 | $ 555 | $ 324 | $ 2,209 |
| 2036 | $ 1,348 | $ 562 | $ 328 | $ 2,239 |
| 30 Yr NPV at 3% | $ 16,041 | $ 7,169 | $ 3,934 | $ 27,144 |
| 30 Yr NPV at 7% | $ 8,134 | $ 3,652 | $ 1,976 | $ 13,762 |

## 8.6 Emission Reductions

Table 8.6-1 presents the emission reductions estimated to result from the fuel program in conjunction with the new engine standards. Also presented are reductions associated with a fuel-only scenario. A complete discussion of these emission reductions and how they were generated can be found in Chapter 3.

Table 8.6-1
Emission Reductions Associated with the NRT4 Final Fuel and Engine Program
and the Fuel-only Scenario (tons)

| Year | NRT4 Fuel and Engine Program | | | NRLM Fuel-only Program | |
|---|---|---|---|---|---|
| | PM | NOx+NMHC | SOx | PM | SOx |
| 2007 | 10,700 | 0 | 133,000 | 10,700 | 133,000 |
| 2008 | 19,500 | 200 | 235,400 | 19,000 | 235,400 |
| 2009 | 20,400 | 400 | 240,100 | 19,400 | 240,100 |
| 2010 | 22,300 | 700 | 255,500 | 20,600 | 255,500 |
| 2011 | 25,900 | 19,100 | 268,600 | 21,600 | 268,600 |
| 2012 | 32,100 | 49,600 | 277,800 | 22,400 | 277,700 |
| 2013 | 39,200 | 84,400 | 285,700 | 23,000 | 285,500 |
| 2014 | 46,900 | 143,600 | 291,600 | 23,500 | 291,500 |
| 2015 | 54,900 | 203,000 | 297,400 | 24,000 | 297,300 |
| 2016 | 62,400 | 261,100 | 302,600 | 24,400 | 302,400 |
| 2017 | 69,600 | 316,900 | 307,700 | 24,800 | 307,500 |
| 2018 | 76,400 | 368,500 | 312,900 | 25,200 | 312,700 |
| 2019 | 82,800 | 417,300 | 318,300 | 25,600 | 318,000 |
| 2020 | 88,800 | 463,000 | 323,300 | 26,000 | 323,100 |
| 2021 | 94,400 | 504,400 | 328,300 | 26,400 | 328,000 |
| 2022 | 99,700 | 542,400 | 333,600 | 26,900 | 333,400 |
| 2023 | 104,600 | 578,100 | 338,800 | 27,300 | 338,500 |
| 2024 | 109,400 | 611,100 | 344,000 | 27,700 | 343,700 |
| 2025 | 113,900 | 642,300 | 349,200 | 28,100 | 348,900 |
| 2026 | 118,200 | 671,400 | 354,400 | 28,500 | 354,100 |
| 2027 | 122,300 | 698,200 | 359,600 | 28,900 | 359,300 |
| 2028 | 125,900 | 723,200 | 364,800 | 29,400 | 364,500 |
| 2029 | 129,500 | 746,900 | 370,000 | 29,800 | 369,700 |
| 2030 | 132,900 | 768,500 | 375,300 | 30,200 | 374,900 |
| 2031 | 136,000 | 788,800 | 380,500 | 30,600 | 380,100 |
| 2032 | 139,100 | 808,400 | 385,800 | 31,000 | 385,400 |
| 2033 | 142,100 | 827,300 | 391,000 | 31,500 | 390,600 |
| 2034 | 145,000 | 845,600 | 396,300 | 31,900 | 395,900 |
| 2035 | 147,800 | 863,100 | 401,600 | 32,300 | 401,200 |
| 2036 | 150,500 | 880,100 | 406,900 | 32,700 | 406,400 |
| 30 Yr NPV at 3% | 1,430,500 | 7,077,900 | 5,725,900 | 461,000 | 5,722,100 |
| 30 Yr NPV at 7% | 690,800 | 3,142,700 | 3,164,100 | 254,800 | 3,162,300 |

[b] Note that the SOx reductions for the Final program and the fuel-only scenario are nearly identical while the PM reductions are very different. This is a result of there being no new engine standards under the fuel-only scenario and, therefore, no CDPFs added to new engines.

## 8.7 Cost per Ton

We have calculated the cost per ton of the final rule 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 the costs and emission reductions from the final rule, including costs incurred and emission reductions generated by both the new and 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 is meant to capture both the early period of the program when there are a small number of compliant engines in the fleet, and the later period when there is nearly complete turnover to compliant engines. The final rule also requires reduced sulfur content in NRLM diesel fuel with a 500 ppm cap beginning in 2007, a 15 ppm NR cap beginning in 2010, and a 15 ppm L&M cap beginning in 2012.

In Section 8.7.1 we present the cost per ton for the NRT4 final engine and fuel program—this represents the cost per ton of this final rule including all costs and emissions reductions associated with the new fuel standards and the new engine standards. In Section 8.7.2 we present the cost per ton for the fuel-only scenario—this scenario would include the same fuel standards as the full engine and fuel program but no new engine standards. In Section 8.7.3 we present two different sets of cost per ton information—cost per ton of a 500 ppm fuel scenario should it remain in place forever with no new engine standards, and the incremental cost per ton of the 15 ppm L&M portion of the fuel program. In Section 8.7.4, we summarize all the cost per ton calculations presented in Sections 8.7.1 through 8.7.3. In Appendix 8A, we present the cost per ton of two sensitivity cases—the case 1 sensitivity shows the cost per ton using future projections of fuel demand developed by the Energy Information Administration; and, the case 2 sensitivity shows the cost per ton if we increase the percentage of mobile versus stationary generator sets (i.e., increase the number of generator sets that will meet the new standards) and increase the usage rates for some >750hp equipment. The rationale for choosing these two sensitivity cases is presented in section 8A.1.

### 8.7.1 Cost per Ton for the NRT4 Final Rule

The NRT4 final rule adopts fuel requirements in two steps—reducing NRLM sulfur levels from current uncontrolled levels to 500 ppm in 2007 and then controlling NR fuel and L&M fuel to 15 ppm in 2010 and 2012, respectively. Beginning June 1, 2007, refiners must produce NRLM diesel fuel that meets a maximum sulfur level of 500 ppm. Then, beginning in June 1, 2010, NR fuel must meet a maximum sulfur level of 15 ppm and, beginning in June 1, 2012, L&M fuel must meet a maximum sulfur level of 15 ppm. This program also adopts new Tier 4 engine standards for nonroad diesel engines that begin in different years for different power categories. See Table 1 in the Executive Summary for details on the new engine standards and when they are implemented. All nonroad diesel-fueled engines with a CDPF must be refueled with the new 15 ppm diesel fuel.

The costs of the final rule include costs associated with both steps in the fuel program (500 ppm and 15 ppm) and costs for the engine standards including equipment modifications. Maintenance costs and savings realized by both the existing fleet (nonroad, locomotive, and marine), future locomotive and marine engines, and the new fleet of nonroad engines complying with the new emissions standards are included. Figure 8.7-1 presents in graphic form the cost of the final rule. These costs are summarized in Table 8.5-1. The cost streams include the amortized capital (fixed) costs and variable costs.

Figure 8.7-1
Estimated Aggregate Cost of the NRT4 Final Rule

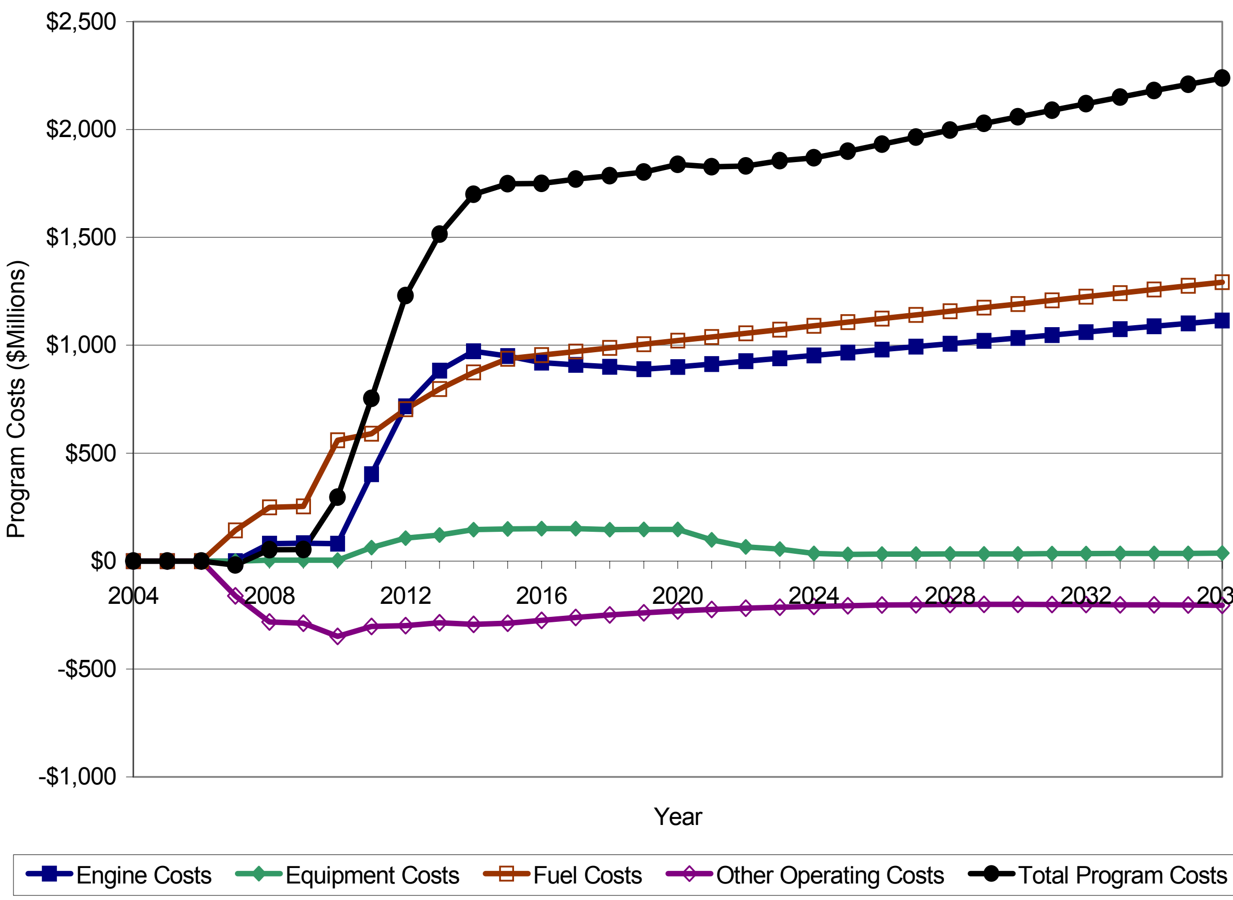


Figure 8.7-1 shows that total annual costs are estimated to be $50 million in the first year the new engine standards apply, increasing to $2.2 billion in 2036 as increasing numbers of engines become subject to the new standards and an ever increasing amount of fuel is consumed. As shown in Table 8.5-1, the 30-year net present value of the costs for this program is estimated as $27.1 billion using a three percent discount rate.

The calculations of cost per ton of each emission reduced under the final 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 $7.2 billion for NOx+NMHC, $16.0 billion for PM and $3.9 billion for SOx. The 30-year net present value, with a three percent discount rate, of emission reductions are 7.1 million tons for NOx+NMHC, 1.4 million tons for PM and 5.7 million tons for SOx (see Table 8.6-1). Our air quality analysis, emissions reduction analysis, and benefits analysis are found in Chapters 2, 3, and 9, respectively.

The cost per ton of emissions reduced for the NRT4 final rule is 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 8.7-1.

Table 8.7-1
Aggregate Costs and Costs per Ton for the NRT4 Final Rule
30-year Net Present Values at a 3% and 7% Discount Rate ($2002)

| Item | Units | 3% discount rate | 7% discount rate | Source |
|---|---|---|---|---|
| 500ppm at $0.021/gal, 2007-2010 | ($10^6$ gallons) | 29,690 | 25,207 | Table 8.4-1 |
| 500ppm at $0.033/gal, 2010-2012 | ($10^6$ gallons) | 7,068 | 5,500 | Table 8.4-1 |
| 500ppm at $0.035/gal, 2012-2014 | ($10^6$ gallons) | 1,660 | 1,196 | Table 8.4-1 |
| 15ppm at $0.058/gal, 2010-2012 | ($10^6$ gallons) | 15,223 | 11,715 | Table 8.4-1 |
| 15ppm at $0.064/gal, 2012-2014 | ($10^6$ gallons) | 17,998 | 12,800 | Table 8.4-1 |
| 15ppm at $0.070/gal, 2014+ | ($10^6$ gallons) | 191,091 | 89,805 | Table 8.4-1 |
| 500ppm Fuel Cost | ($million) | $915 | $753 | Table 8.4-1 |
| 15ppm Fuel Cost | ($million) | $15,411 | $7,785 | Table 8.4-1 |
| Other Operating Costs* | ($million) | -$4,517 | -$2,745 | Table 8.4-5 |
| Engine Costs | ($million) | $14,054 | $7,215 | Table 8.5-1 |
| Equipment Costs | ($million) | $1,281 | $754 | Table 8.5-1 |
| Total Program Costs | ($million) | $27,144 | $13,762 | Table 8.5-1 |
| NOx+NMHC Costs | ($million) | $7,169 | $3,652 | Table 8.5-2 |
| PM Costs | ($million) | $16,041 | $8,134 | Table 8.5-2 |
| SOx Costs | ($million) | $3,934 | $1,976 | Table 8.5-2 |
| NOx+NMHC Reduction | ($10^6$ tons) | 7.1 | 3.1 | Table 8.6-1 |
| PM Reduction | ($10^6$ tons) | 1.4 | 0.7 | Table 8.6-1 |
| SOx Reduction | ($10^6$ tons) | 5.7 | 3.2 | Table 8.6-1 |
| Cost per Ton NOx+NMHC | ($/ton) | $1,010 | $1,160 | Calculated |
| Cost per Ton PM | ($/ton) | $11,200 | $11,800 | Calculated |
| Cost per Ton | ($/ton) | $690 | $620 | Calculated |

* Other operating costs include oil change maintenance savings, CDPF and CCV maintenance costs, and CDPF regeneration costs.

We have also calculated the cost per ton of emissions reduced in the year 2030 using the annual costs and emission reductions in that year alone. This number, shown in Table 8.7-2, 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 NRT4 Final Rule
Annual Values without Discounting ($2002)

| Pollutant | Long-Term Cost per Ton in 2030 |
|---|---|
| NOx+NMHC | $680 |
| PM | $9,300 |
| SOx | $810 |

### 8.7.2 Cost per Ton for the NRLM Fuel-only Scenario

The costs of the fuel-only scenario include costs associated with both steps in the fuel program absent any new engine standards. Oil change maintenance savings would be realized by both the existing fleet and the new fleet of engines as these savings are not dependent on any new engine standards. Figure 8.7-2 presents in graphic form the cost of the fuel-only scenario. These costs are summarized in Table 8.4-7. The cost streams include the amortized capital (fixed) costs and variable costs.

Figure 8.7-2
Estimated Aggregate Cost of the NRLM Fuel-only Scenario

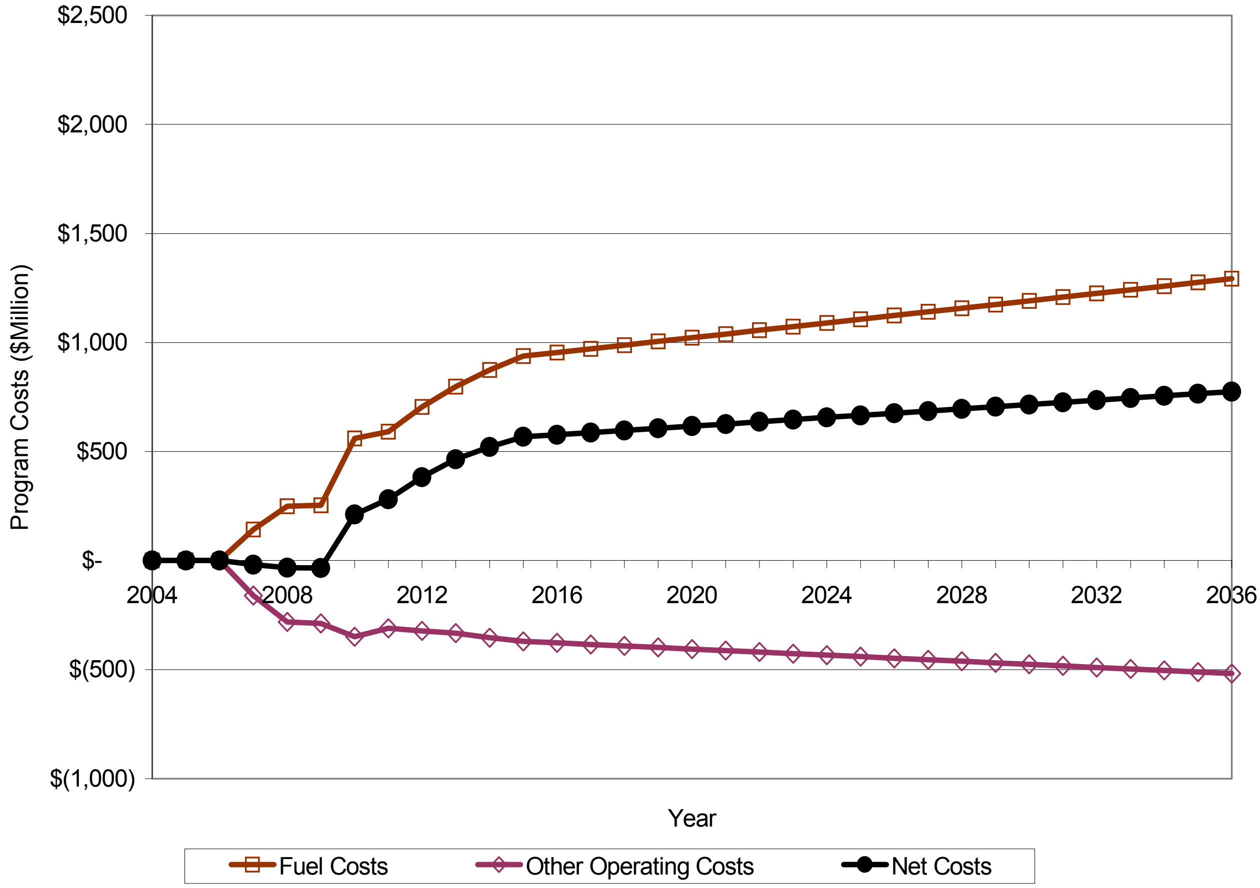


Figure 8.7-2 shows that total annual costs are estimated to be -$33 million in the first full year of the new fuel standards (i.e., a $33 million savings), increasing to $775 million in 2036 as an ever increasing amount of fuel is consumed. As shown in Table 8.4-7, the 30-year net present value of the fuel-only scenario is estimated as $9.2 billion using a three percent discount rate.

The calculations of cost per ton of each emission reduced under the fuel-only scenario divides the net present value of the annual costs assigned to each pollutant (see Table 8.4-7 for costs by pollutant and Table 8.4-6 for how we have allocated costs by pollutant) by the net present value of the total annual reductions of each pollutant. The 30-year net present value of the costs associated with each pollutant, calculated with a three percent discount rate, are shown in Table 8.4-7 as $3.1 billion for PM and $6.1 billion for SOx. If we exclude the oil change maintenance savings, the costs of the fuel-only scenario would be $5.4 billion for PM and $10.9 billion for SOx. The 30-year net present value, with a three percent discount rate, of emission reductions are 461 thousand tons for PM and 5.7 million tons for SOx. Our air quality analysis, emissions reduction analysis, and benefits analysis are found in Chapters 2, 3, and 9, respectively. Table 8.7-4 presents the cost per ton results for the fuel-only scenario including the oil change maintenance savings and excluding those savings.

Table 8.7-4
Aggregate Costs and Costs per Ton for the Fuel-only Scenario
30-year Net Present Values at a 3% and 7% Discount Rate ($2002)

| Item | Units | 3% discount rate | 7% discount rate | Source |
|---|---|---|---|---|
| 500ppm at $0.021/gal, 2007-2010 | ($10^6$ gallons) | 29,690 | 25,207 | Table 8.4-1 |
| 500ppm at $0.033/gal, 2010-2012 | ($10^6$ gallons) | 7,068 | 5,500 | Table 8.4-1 |
| 500ppm at $0.035/gal, 2012-2014 | ($10^6$ gallons) | 1,660 | 1,196 | Table 8.4-1 |
| 15ppm at $0.058/gal, 2010-2012 | ($10^6$ gallons) | 15,223 | 11,715 | Table 8.4-1 |
| 15ppm at $0.064/gal, 2012-2014 | ($10^6$ gallons) | 17,998 | 12,800 | Table 8.4-1 |
| 15ppm at $0.070/gal, 2014+ | ($10^6$ gallons) | 191,091 | 89,805 | Table 8.4-1 |
| 500ppm Fuel Cost | ($million) | $915 | $753 | Table 8.4-1 |
| 15ppm Fuel Cost | ($million) | $15,411 | $7,785 | Table 8.4-1 |
| Other Operating Costs* | ($million) | -$4,517 | -$2,745 | Table 8.4-7 |
| Total Costs (w/ maintenance savings) | ($million) | $9,194 | $4,618 | Table 8.4-7 |
| Total Costs (w/o maintenance savings) | ($million) | $16,326 | $8,538 | Table 8.4-7 |
| PM Costs (w/ maintenance savings) | ($million) | $3,065 | $1,539 | Table 8.4-7 |
| PM Costs (w/o maintenance savings) | ($million) | $5,442 | $2,846 | Calculated** |
| SOx Costs (w/ maintenance savings) | ($million) | $6,130 | $3,079 | Table 8.4-7 |
| SOx Costs (w/o maintenance savings) | ($million) | $10,884 | $5,692 | Calculated** |
| PM Reduction | ($10^6$ tons) | 0.46 | 0.26 | Table 8.6-1 |
| SOx Reduction | ($10^6$ tons) | 5.7 | 3.2 | Table 8.6-1 |
| Cost per Ton PM (w/ maintenance savings) | ($/ton) | $6,600 | $6,000 | Calculated |
| Cost per Ton PM (w/o maintenance savings) | ($/ton) | $11,800 | $11,200 | Calculated |
| Cost per Ton SOx (w/ maintenance savings) | ($/ton) | $1,070 | $970 | Calculated |
| Cost per Ton Sox (w/o maintenance savings) | ($/ton) | $1,900 | $1,800 | Calculated |

* Other operating costs include oil change maintenance savings.
** Calculated as one-third (PM) or two-thirds (SOx) of the Total Scenario Costs w/o maintenance savings.

We have also calculated the cost per ton of emissions reduced in the year 2030 using the annual costs and emission reductions in that year alone. This number, shown in Table 8.7-5, approaches the long-term cost per ton of emissions reduced.

Table 8.7-5
Long-Term Cost per Ton of the NRT4 Fuel-only Scenario
Annual Values without Discounting ($2002)

| Pollutant | Long-Term Cost per Ton in 2030 |
|---|---|
| PM (with maintenance savings) | $7,900 |
| PM (without maintenance savings) | $13,200 |
| SOx (with maintenance savings) | $1,270 |
| SOx (without maintenance savings) | $2,100 |

### 8.7.3 Costs and Costs per Ton for Other Control Scenarios

Here we look at the costs and costs per ton of other control scenarios. Specifically, we look at the cost per ton of the 500 ppm NRLM fuel scenario should it continue forever without any new engine standards. We also look at the incremental cost per ton of the 15 ppm L&M fuel scenario.

#### 8.7.3.1 Costs and Costs per Ton of a 500 ppm NRLM Fuel-only Scenario

A 500 ppm NRLM fuel-only scenario would mirror the fuel-only scenario discussed above with the exception that no 15 ppm fuel step would occur. The incremental fuel cost would be $0.021 per gallon during the years 2007 through 2010 and then $0.022 per gallon thereafter (see Table 7.5-1). The oil change maintenance savings would be $0.029 per gallon for NR and $0.010 per gallon for L&M (see Table 8.4-2). Tables 8.7-6 and 8.7-7 present the fuel costs and oil change maintenance savings, respectively, associated with a 500 ppm NRLM fuel-only scenario.

Table 8.7-6
Aggregate Fuel Costs of a 500 ppm NRLM Fuel-only Scenario ($2002)

| Year | Affected NR Fuel 500 ppm ($10^6$ gallons) | Affected L&M Fuel 500 ppm ($10^6$ gallons) | Fuel Cost* 500 ppm ($/gal) | NRLM Fuel Costs ($10^6$ dollars) |
|---|---|---|---|---|
| 2007 | 4,790 | 1,990 | $ 0.021 | $ 142 |
| 2008 | 8,406 | 3,454 | $ 0.021 | $ 249 |
| 2009 | 8,599 | 3,498 | $ 0.021 | $ 254 |
| 2010 | 8,400 | 3,457 | $ 0.022 | $ 256 |
| 2011 | 8,300 | 3,450 | $ 0.022 | $ 258 |
| 2012 | 8,479 | 3,489 | $ 0.022 | $ 263 |
| 2013 | 8,659 | 3,518 | $ 0.022 | $ 268 |
| 2014 | 8,839 | 3,552 | $ 0.022 | $ 273 |
| 2015 | 9,018 | 3,586 | $ 0.022 | $ 277 |
| 2016 | 9,196 | 3,623 | $ 0.022 | $ 282 |
| 2017 | 9,374 | 3,659 | $ 0.022 | $ 287 |
| 2018 | 9,552 | 3,699 | $ 0.022 | $ 292 |
| 2019 | 9,730 | 3,747 | $ 0.022 | $ 296 |
| 2020 | 9,907 | 3,781 | $ 0.022 | $ 301 |
| 2021 | 10,085 | 3,812 | $ 0.022 | $ 306 |
| 2022 | 10,263 | 3,859 | $ 0.022 | $ 311 |
| 2023 | 10,441 | 3,897 | $ 0.022 | $ 315 |
| 2024 | 10,619 | 3,939 | $ 0.022 | $ 320 |
| 2025 | 10,797 | 3,980 | $ 0.022 | $ 325 |
| 2026 | 10,973 | 4,022 | $ 0.022 | $ 330 |
| 2027 | 11,150 | 4,064 | $ 0.022 | $ 335 |
| 2028 | 11,326 | 4,106 | $ 0.022 | $ 340 |
| 2029 | 11,503 | 4,148 | $ 0.022 | $ 344 |
| 2030 | 11,679 | 4,190 | $ 0.022 | $ 349 |
| 2031 | 11,856 | 4,232 | $ 0.022 | $ 354 |
| 2032 | 12,032 | 4,275 | $ 0.022 | $ 359 |
| 2033 | 12,209 | 4,318 | $ 0.022 | $ 364 |
| 2034 | 12,386 | 4,360 | $ 0.022 | $ 368 |
| 2035 | 12,562 | 4,403 | $ 0.022 | $ 373 |
| 2036 | 12,739 | 4,447 | $ 0.022 | $ 378 |
| 30 Yr NPV at 3% | 179,520 | 68,639 | | $ 5,428 |
| 30 Yr NPV at 7% | 99,928 | 38,879 | | $ 3,027 |

* Fuel costs are relative to uncontrolled fuel and assume that, during the transitional years of 2010 & 2014, the first 5 months are at the previous year's cost and the remaining 7 months are at the next year's cost.
See Appendix 8B for how these fuel volumes were developed.

Table 8.7-7
Oil-Change Maintenance Savings Associated with a 500 ppm NRLM Fuel-only Scenario
($2002)

| Year | Affected NR Fuel 500 ppm ($10^6$ gallons) | Affected L&M Fuel 500 ppm ($10^6$ gallons) | NR Savings savings=$0.029/gal ($10^6$ dollars) | L&M Savings savings=$0.010/gal ($10^6$ dollars) | NRLM Total Savings ($10^6$ dollars) |
|---|---|---|---|---|---|
| 2007 | 4,790 | 1,990 | $ 140 | $ 21 | $ 161 |
| 2008 | 8,406 | 3,454 | $ 246 | $ 36 | $ 282 |
| 2009 | 8,599 | 3,498 | $ 251 | $ 37 | $ 288 |
| 2010 | 8,400 | 3,457 | $ 246 | $ 36 | $ 282 |
| 2011 | 8,300 | 3,450 | $ 243 | $ 36 | $ 279 |
| 2012 | 8,479 | 3,489 | $ 248 | $ 37 | $ 284 |
| 2013 | 8,659 | 3,518 | $ 253 | $ 37 | $ 290 |
| 2014 | 8,839 | 3,552 | $ 258 | $ 37 | $ 296 |
| 2015 | 9,018 | 3,586 | $ 264 | $ 38 | $ 301 |
| 2016 | 9,196 | 3,623 | $ 269 | $ 38 | $ 307 |
| 2017 | 9,374 | 3,659 | $ 274 | $ 38 | $ 312 |
| 2018 | 9,552 | 3,699 | $ 279 | $ 39 | $ 318 |
| 2019 | 9,730 | 3,747 | $ 284 | $ 39 | $ 324 |
| 2020 | 9,907 | 3,781 | $ 290 | $ 40 | $ 329 |
| 2021 | 10,085 | 3,812 | $ 295 | $ 40 | $ 335 |
| 2022 | 10,263 | 3,859 | $ 300 | $ 40 | $ 340 |
| 2023 | 10,441 | 3,897 | $ 305 | $ 41 | $ 346 |
| 2024 | 10,619 | 3,939 | $ 310 | $ 41 | $ 352 |
| 2025 | 10,797 | 3,980 | $ 316 | $ 42 | $ 357 |
| 2026 | 10,973 | 4,022 | $ 321 | $ 42 | $ 363 |
| 2027 | 11,150 | 4,064 | $ 326 | $ 43 | $ 369 |
| 2028 | 11,326 | 4,106 | $ 331 | $ 43 | $ 374 |
| 2029 | 11,503 | 4,148 | $ 336 | $ 43 | $ 380 |
| 2030 | 11,679 | 4,190 | $ 341 | $ 44 | $ 385 |
| 2031 | 11,856 | 4,232 | $ 347 | $ 44 | $ 391 |
| 2032 | 12,032 | 4,275 | $ 352 | $ 45 | $ 397 |
| 2033 | 12,209 | 4,318 | $ 357 | $ 45 | $ 402 |
| 2034 | 12,386 | 4,360 | $ 362 | $ 46 | $ 408 |
| 2035 | 12,562 | 4,403 | $ 367 | $ 46 | $ 413 |
| 2036 | 12,739 | 4,447 | $ 372 | $ 47 | $ 419 |
| 30 Yr NPV at 3% | 179,520 | 68,639 | $ 5,248 | $ 719 | $ 5,967 |
| 30 Yr NPV at 7% | 99,928 | 38,879 | $ 2,921 | $ 407 | $ 3,328 |

Table 8.7-8 presents the annual net operating costs (Tables 8.7-6 and 8.7-7) along with the costs by pollutant associated with a 500 ppm NRLM fuel-only scenario. Because a 500 ppm NRLM fuel-only scenario is analogous to the NRT4 fuel-only scenario discussed above (i.e., no new engine standards and, thus, only fuel-derived benefits will occur), we would allocate costs to PM and SOx the same way as the NRT4 fuel-only scenario (see Table 8.4-6) except that costs for 15 ppm fuel would clearly be zero. Table 8.7-8 also presents the emission reductions that would result from a 500 ppm NRLM fuel-only scenario.

Table 8.7-8
Aggregate Net Operating Costs, Costs by Pollutant, and Emissions Reductions
Associated with a 500 ppm NRLM Fuel-only Scenario ($2002)

| Year | Fuel Costs ($million) | Other Operating Costs ($million) | Net Operating Costs ($million) | SOx Costs ($million) | PM Costs ($million) | PM Reduction (tons) | SOx Reduction (tons) |
|---|---|---|---|---|---|---|---|
| 2007 | $ 142 | $ (161) | $ (18) | $ (12) | $ (6) | 10,700 | 133,000 |
| 2008 | $ 249 | $ (282) | $ (33) | $ (22) | $ (11) | 19,000 | 235,400 |
| 2009 | $ 254 | $ (288) | $ (34) | $ (23) | $ (11) | 19,400 | 240,100 |
| 2010 | $ 256 | $ (282) | $ (26) | $ (17) | $ (9) | 19,700 | 244,000 |
| 2011 | $ 258 | $ (279) | $ (20) | $ (14) | $ (7) | 20,000 | 248,500 |
| 2012 | $ 263 | $ (284) | $ (21) | $ (14) | $ (7) | 20,400 | 253,100 |
| 2013 | $ 268 | $ (290) | $ (22) | $ (15) | $ (7) | 20,800 | 257,600 |
| 2014 | $ 273 | $ (296) | $ (23) | $ (15) | $ (8) | 21,100 | 262,200 |
| 2015 | $ 277 | $ (301) | $ (24) | $ (16) | $ (8) | 21,500 | 266,700 |
| 2016 | $ 282 | $ (307) | $ (25) | $ (17) | $ (8) | 21,900 | 271,300 |
| 2017 | $ 287 | $ (312) | $ (26) | $ (17) | $ (9) | 22,200 | 275,800 |
| 2018 | $ 292 | $ (318) | $ (26) | $ (18) | $ (9) | 22,600 | 280,400 |
| 2019 | $ 296 | $ (324) | $ (27) | $ (18) | $ (9) | 23,000 | 285,200 |
| 2020 | $ 301 | $ (329) | $ (28) | $ (19) | $ (9) | 23,300 | 289,700 |
| 2021 | $ 306 | $ (335) | $ (29) | $ (19) | $ (10) | 23,700 | 294,200 |
| 2022 | $ 311 | $ (340) | $ (30) | $ (20) | $ (10) | 24,100 | 299,000 |
| 2023 | $ 315 | $ (346) | $ (31) | $ (20) | $ (10) | 24,500 | 303,600 |
| 2024 | $ 320 | $ (352) | $ (31) | $ (21) | $ (10) | 24,800 | 308,200 |
| 2025 | $ 325 | $ (357) | $ (32) | $ (21) | $ (11) | 25,200 | 312,900 |
| 2026 | $ 330 | $ (363) | $ (33) | $ (22) | $ (11) | 25,600 | 317,500 |
| 2027 | $ 335 | $ (369) | $ (34) | $ (23) | $ (11) | 25,900 | 322,200 |
| 2028 | $ 340 | $ (374) | $ (35) | $ (23) | $ (12) | 26,300 | 326,800 |
| 2029 | $ 344 | $ (380) | $ (35) | $ (24) | $ (12) | 26,700 | 331,500 |
| 2030 | $ 349 | $ (385) | $ (36) | $ (24) | $ (12) | 27,100 | 336,200 |
| 2031 | $ 354 | $ (391) | $ (37) | $ (25) | $ (12) | 27,400 | 340,800 |
| 2032 | $ 359 | $ (397) | $ (38) | $ (25) | $ (13) | 27,800 | 345,500 |
| 2033 | $ 364 | $ (402) | $ (39) | $ (26) | $ (13) | 28,200 | 350,200 |
| 2034 | $ 368 | $ (408) | $ (39) | $ (26) | $ (13) | 28,600 | 354,900 |
| 2035 | $ 373 | $ (413) | $ (40) | $ (27) | $ (13) | 29,000 | 359,700 |
| 2036 | $ 378 | $ (419) | $ (41) | $ (27) | $ (14) | 29,300 | 364,400 |
| 30 Yr NPV at 3% | $ 5,428 | $ (5,967) | $ (539) | $ (359) | $ (180) | 419,800 | 5,210,600 |
| 30 Yr NPV at 7% | $ 3,027 | $ (3,328) | $ (301) | $ (201) | $ (100) | 233,800 | 2,901,700 |

The calculations of cost per ton of each emission reduced under the 500 ppm NRLM fuel-only scenario divides the net present value of the annual costs assigned to each pollutant (see Table 8.7-8) by the net present value of the total annual reductions of each pollutant (Table 8.7-8). The 30-year net present value of the costs (remember that negative costs are actually savings) associated with each pollutant, calculated with a three percent discount rate, are shown in Table 8.7-8 as -$107 million for PM and -$213 million for SOx. If we exclude the oil change maintenance savings, the costs of the fuel-only scenario would be $1.9 billion for PM and $3.8 billion for SOx. The 30-year net present value, with a three percent discount rate, of emission reductions are 420 thousand tons for PM and 5.2 million tons for SOx. Our air quality analysis, emissions reduction analysis, and benefits analysis are found in Chapters 2, 3, and 9, respectively. Table 8.7-9 presents the cost per ton results for the 500 ppm NRLM fuel-only scenario including the oil change maintenance savings and excluding those savings.

Table 8.7-9
Aggregate Cost per Ton for the 500 ppm NRLM Fuel-only Scenario
30-year Net Present Values at a 3% and 7% Discount Rate ($2002)

| Item | Units | 3% discount rate | 7% discount rate | Source |
|---|---|---|---|---|
| 500ppm at $0.021/gal, 2007-2010 | ($10^6$ gallons) | 31,316 | 26,500 | Table 8.7-6 |
| 500ppm at $0.022/gal, 2010+ | ($10^6$ gallons) | 216,843 | 112,307 | Table 8.7-6 |
| 500ppm Fuel Cost | ($million) | $5,428 | $3,027 | Table 8.7-6 |
| Other Operating Costs* | ($million) | -$5,967 | -$3,328 | Table 8.7-7 |
| Total Costs (w/ maintenance savings) | ($million) | -$539 | -$301 | Table 8.7-7 |
| Total Costs (w/o maintenance savings) | ($million) | $5,428 | $3,027 | Table 8.7-7 |
| PM Costs (w/ maintenance savings) | ($million) | -$180 | -$100 | Table 8.7-8 |
| PM Costs (w/o maintenance savings) | ($million) | $1,809 | $1,009 | Calculated** |
| SOx Costs (w/ maintenance savings) | ($million) | -$359 | -$201 | Table 8.7-8 |
| SOx Costs (w/o maintenance savings) | ($million) | $3,619 | $2,018 | Calculated** |
| PM Reduction | ($10^6$ tons) | 0.42 | 0.23 | Table 8.7-8 |
| SOx Reduction | ($10^6$ tons) | 5.2 | 2.9 | Table 8.7-8 |
| Cost per Ton PM (w/ maintenance savings) | ($/ton) | -$400 | -$400 | Calculated |
| Cost per Ton PM (w/o maintenance savings) | ($/ton) | $4,300 | $4,400 | Calculated |
| Cost per Ton SOx (w/ maintenance savings) | ($/ton) | -$70 | -$70 | Calculated |
| Cost per Ton Sox (w/o maintenance savings) | ($/ton) | $690 | $700 | Calculated |

* Other operating costs include oil change maintenance savings.
** Calculated as one-third (PM) or two-thirds (SOx) of the Total Scenario Costs w/o maintenance savings.

We have also calculated the cost per ton of emissions reduced in the year 2030 using the annual costs and emission reductions in that year alone. This number, shown in Table 8.7-10, approaches the long-term cost per ton of emissions reduced.

Table 8.7-10
Long-Term Cost per Ton of the 500 ppm NRLM Fuel-only Scenario
Annual Values without Discounting ($2002)

| Pollutant | Long-Term Cost per Ton in 2030 |
|---|---|
| PM (with maintenance savings) | -$400 |
| PM (without maintenance savings) | $4,300 |
| SOx (with maintenance savings) | -$70 |
| SOx (without maintenance savings) | $690 |

### 8.7.3.2 Costs and Costs per Ton of the 15 ppm L&M Fuel Increment

In this section, we evaluate the incremental cost per ton of the 15 ppm L&M fuel cap in 2012 (final NRLM program) relative to retaining the 500 ppm cap on L&M fuel (the proposed NRLM program) indefinitely. Nonroad diesel fuel is assumed to be subject to a 15 ppm cap starting in 2010 in both cases. We assume that the emission standards applicable to nonroad engines are the same regardless of the sulfur cap applicable to L&M fuel. Therefore, the only differences between the 500 and 15 ppm cap on L&M fuel are in emissions of $SO_2$ and sulfate PM, fuel costs and engine maintenance savings. The cost of complying with emission standards for land-based nonroad equipment, as well as HC, NOx, and non-sulfate PM emissions from this equipment are unaffected.

The difference in costs between the two L&M fuel caps are primarily related to the production 15 ppm L&M fuel. The differences in sulfurous emissions arise from differences in the sulfur content of both L&M fuel and, in the Northeast/Middle Atlantic area, heating oil. While the difference in heating oil sulfur content is a direct result of the final NRLM fuel provisions for the Northeast/Middle Atlantic area, heating oil sulfur content is not directly regulated by this final rule. Therefore, we develop estimates of the incremental cost effectiveness of the 15 ppm L&M fuel cap both with and without the changes in heating oil sulfur. However, we believe that the most appropriate estimate of the incremental cost effectiveness of the 15 ppm L&M fuel cap is that including the change in heating oil sulfur content.

The key inputs to this sensitivity analysis are: 1) the volumes and sulfur contents of each type of distillate fuel being produced and consumed in the 2012-2036 timeframe, and 2) the cost of supplying these fuels over the same timeframe. The fuels produced prior to June 1, 2012 are identical under the two scenarios being evaluated here. Thus, we ignore all emissions and costs prior to June 1, 2012. This incremental analysis models the U.S. minus California., although it would also apply for the total U.S. as well since California's fuel quality is not expected to change with the requirement that L&M fuel meet a 15 ppm cap.

The process for estimating the annual production volumes of each fuel was described in Chapter 7. The first step in the process was to develop a comprehensive description of fuel production and demand in 2001 for non-highway and highway diesel fuel which accounted for the spillover of low sulfur, highway fuel into the non-highway markets. The analysis also considered the downgrade of jet fuel and highway diesel fuel, along with some gasoline, to lower quality fuels during pipeline distribution.

We then developed a set of analogous estimates for 2014, starting with demand. Fuel demand in 2014 was projected using the EPA draft NONROAD2004 model and EIA's AEO 2003. We also estimated the volume of highway diesel fuel demand considering the highway diesel fuel requirements being implemented in 2006 and 2010. Spillover of highway fuel into the non-highway markets was assumed to remain constant (in terms of the percentage of each non-highway market represented by spillover). The volume of gasoline, jet fuel and highway diesel fuel in 2014 downgraded to 500 ppm and high sulfur distillate was projected to increase in proportion to the growth in jet fuel demand and the supply of highway diesel fuel. This downgraded fuel was first distributed to the non-highway fuel markets assuming sulfur controls on highway fuel only, followed by the 500 ppm standard on NRLM fuel in 2007 and subsequent 15 ppm standards on nonroad fuel and L&M fuel in 2010 and 2012, respectively. NRLM fuel not already complying with the required sulfur limit prior to the NRLM rule from spillover of highway fuel or downgrade, had to be desulfurized at refineries.

We then used these 2014 estimates of fuel production, downgrade and spillover to develop similar estimates for individual calendar years starting with 2007 and going through 2040 consistent with the phase of NRLM program in place at the time. These individual, annual estimates were based on a slightly more approximate methodology which assumed that the fraction of each non-highway distillate fuel's market demand represented by spillover and downgrade remained constant at its 2014 level. Regarding spillover, this is the same assumption made in developing our estimate of spillover in 2014. However, with respect to downgrade, this assumption differs from that used in the more comprehensive 2014 analysis. Because the demand for jet fuel and highway diesel fuel is projected to grow faster than that for NRLM fuel and heating oil, the percentage of downgrade in the NRLM and heating oil markets is higher in 2014 than in 2001. Thus, the net effect of assuming that the percentage of downgrade remains constant at 2014 levels underestimates the percentage of downgrade in the non-highway fuel markets after 2014, and overestimates it prior to 2014.

The effect of assuming constant downgrade percentages in the non-highway markets on the estimated costs and benefits of the overall rule is very small, given that it affects only a small portion of the overall fuel demanded, that none of the benefits of the engine emission standards are involved and that the changes in costs and benefits are offsetting. However, it has a larger impact on this incremental analysis, as about half of the 30-year sulfur dioxide emission benefits of the 15 ppm L&M cap are due to a shift in downgrade from the L&M fuel market to the heating oil market in the Northeast/Middle Atlantic area. Thus, for this incremental analysis, we revised the assumption that the downgrade fraction of the demand for the various non-highway fuels for years other than 2014 will remain constant at their 2014 levels. Instead, we estimated the volume of downgrade generated each year, based on future highway diesel fuel supply and jet fuel demand. We made one simplifying assumption: that highway diesel fuel supply grew at the same rate as highway fuel demand. Highway fuel supply includes spillover to the non-highway fuel markets. While nonroad fuel demand is projected to grow at roughly the same rate as highway fuel, L&M fuel and heating oil demand are expected to grow much more slowly. Thus, this simplifying assumption overestimates highway fuel supply. However, the degree of overestimation is slight, since only about 10% of highway diesel fuel supply is spillover to the non-highway pool, and about 70% of that goes to the nonroad fuel market.

Estimates of the demand for highway and jet fuel through 2025 are taken from EIA's AEO 2003. After 2025 the yearly projected demand for both highway diesel fuel and jet fuel are estimated from the average projected growth from AEO 2003 between 2020 and 2025. The year-over-year growth rates for highway and jet fuel from 2020 to 2025 were 1.019 and 1.021, respectively. The annual demand for highway and jet fuel from 2012 to 2036 and the volume ratios to the projected 2014 volumes are summarized in Table 8.7-11. In last column of Table 8.7-11 an average set of volume ratios are shown which represents the combined growth for highway and jet-based downgrade in heating oil. The relative volume of highway and jet-based downgrade was similar in NRLM diesel fuel, so these volume ratios were used for estimating non-2014 downgrade volumes for NRLM diesel fuel as well.

Table 8.7-11
Projected Highway Diesel Fuel and Jet Fuel Demand - AEO 2003 (Trillion BTU)

| Year | Highway | | Jet Fuel | | Avg Ratio to 2014 |
|---|---|---|---|---|---|
| | Fuel Demand | Ratio to 2014 | Fuel Demand | Ratio to 2014 | |
| 2012 | 7,500 | 0.957 | 4,140 | 0.945 | 0.954 |
| 2013 | 7,670 | 0.978 | 4,260 | 0.973 | 0.977 |
| 2014 | 7,840 | 1.000 | 4,380 | 1.000 | 1.000 |
| 2015 | 7,980 | 1.018 | 4,500 | 1.027 | 1.020 |
| 2016 | 8,110 | 1.034 | 4,620 | 1.055 | 1.039 |
| 2017 | 8,250 | 1.052 | 4,730 | 1.080 | 1.059 |
| 2018 | 8,390 | 1.070 | 4,860 | 1.110 | 1.079 |
| 2019 | 8,560 | 1.092 | 4,970 | 1.135 | 1.102 |
| 2020 | 8,700 | 1.110 | 5,090 | 1.162 | 1.122 |
| 2021 | 8,850 | 1.129 | 5,200 | 1.187 | 1.142 |
| 2022 | 9,020 | 1.151 | 5,310 | 1.212 | 1.165 |
| 2023 | 9,200 | 1.173 | 5,430 | 1.240 | 1.189 |
| 2024 | 9,400 | 1.199 | 5,540 | 1.265 | 1.214 |
| 2025 | 9,580 | 1.222 | 5,660 | 1.292 | 1.238 |
| 2026 | 9,762 | 1.245 | 5,780 | 1.319 | 1.262 |
| 2027 | 9,947 | 1.269 | 5,900 | 1.347 | 1.287 |
| 2028 | 10,140 | 1.293 | 6,020 | 1.375 | 1.312 |
| 2029 | 10,330 | 1.317 | 6,150 | 1.404 | 1.338 |
| 2030 | 10,530 | 1.343 | 6,280 | 1.434 | 1.364 |
| 2031 | 10,730 | 1.368 | 6,410 | 1.464 | 1.390 |
| 2032 | 10,930 | 1.394 | 6,550 | 1.495 | 1.417 |
| 2033 | 11,140 | 1.421 | 6,680 | 1.526 | 1.445 |
| 2034 | 11,350 | 1.447 | 6,820 | 1.558 | 1.473 |
| 2035 | 11,560 | 1.475 | 6,970 | 1.591 | 1.502 |
| 2036 | 11,780 | 1.503 | 7,110 | 1.624 | 1.531 |

The next step is to estimate the annual demand, spillover, downgrade and production volumes for NRLM fuel from 2012 to 2036 for both the proposed and final rule NRLM programs. Starting with the proposed NRLM fuel program, we estimated the jet and highway-based downgrade in the nonroad, locomotive and marine fuel markets from mid-2012 to mid-2014 by multiplying the 2014 highway and jet-based downgrade volumes shown in Table 7.1.4-1 by the ratio of highway and jet fuel demand in each year to 2014 from Table 8.7-11, respectively. For the years following 2014, we multiplied the 2014 highway and jet-based downgrade volumes shown in Table 7.1.4-2 by the ratio of highway and jet fuel demand in each year to 2014 from Table 8.7-11, respectively. Annual demand for NRLM fuel, and the contribution of spillover and small refiner fuel to these markets, were estimated by multiplying the 2014 estimates of these volumes in Tables 7.1.4-1 (for 2012-2014) and 7.1.4-2 (for 2015 and beyond) by the growth in NRLM fuel demand contained in Tables 7.1.5-1 (for nonroad and locomotive fuel) and 7.1.5-2 (for marine fuel). Annual production volumes of NRLM fuel were estimated by subtracting the downgrade, spillover and small refiner fuel volumes from total demand. The resulting estimates of downgrade, spillover, small refiner fuel, and 15 and 500 ppm production volumes for nonroad, locomotive and marine diesel fuel for the proposed rule program are summarized in Tables 8.7-12, 8.7-13 and 8.7-14, respectively. The highway-based and jet fuel-based downgrade volumes are combined together into one column.

Table 8.7-12
Nonroad Fuel Supply Under the Proposed NRLM Fuel Program With the Shift of Downgrade to the Heating Oil Market (million gallons) *

| Year | Downgrade | Small Refiner Fuel | Spillover | New 15 ppm Fuel | Total Volume |
|---|---|---|---|---|---|
| 2012 | 1,061 | 627 | 2,760 | 8,327 | 12,774 |
| 2013 | 1,085 | 640 | 2,818 | 8,501 | 13,045 |
| 2014 | 463 | 272 | 2,940 | 9,641 | 13,316 |
| 2015 | 0 | 0 | 3,047 | 10,539 | 13,586 |
| 2016 | 0 | 0 | 3,107 | 10,747 | 13,854 |
| 2017 | 0 | 0 | 3,167 | 10,955 | 14,122 |
| 2018 | 0 | 0 | 3,227 | 11,162 | 14,390 |
| 2019 | 0 | 0 | 3,288 | 11,370 | 14,658 |
| 2020 | 0 | 0 | 3,352 | 11,578 | 14,926 |
| 2021 | 0 | 0 | 3,408 | 11,786 | 15,193 |
| 2022 | 0 | 0 | 3,468 | 11,993 | 15,461 |
| 2023 | 0 | 0 | 3,528 | 12,201 | 15,729 |
| 2024 | 0 | 0 | 3,588 | 12,409 | 15,997 |
| 2025 | 0 | 0 | 3,648 | 12,616 | 16,265 |
| 2026 | 0 | 0 | 3,708 | 12,823 | 16,531 |
| 2027 | 0 | 0 | 3,767 | 13,029 | 16,797 |
| 2028 | 0 | 0 | 3,827 | 13,236 | 17,063 |
| 2029 | 0 | 0 | 3,887 | 13,443 | 17,329 |
| 2030 | 0 | 0 | 3,946 | 13,649 | 17,595 |
| 2031 | 0 | 0 | 4,006 | 13,855 | 17,861 |
| 2032 | 0 | 0 | 4,066 | 14,062 | 18,127 |
| 2033 | 0 | 0 | 4,125 | 14,268 | 18,393 |
| 2034 | 0 | 0 | 4,185 | 14,474 | 18,659 |
| 2035 | 0 | 0 | 4,245 | 14,681 | 18,925 |
| 2036 | 0 | 0 | 4,304 | 14,887 | 19,191 |

* Excludes NRLM fuel demand in California

Table 8.7-13
Locomotive Volumes Under the Proposed NRLM Fuel Program With the Shift of Downgrade to the Heating Oil Market (million gallons) *

| Year | Downgrade | New 500 ppm Fuel | Spillover | Total Volume |
|---|---|---|---|---|
| 2012 | 579 | 1,705 | 602 | 2,886 |
| 2013 | 593 | 1,710 | 607 | 2,909 |
| 2014 | 1,176 | 1,190 | 566 | 2,932 |
| 2015 | 1,614 | 804 | 539 | 2,956 |
| 2016 | 1,644 | 800 | 544 | 2,988 |
| 2017 | 1,675 | 791 | 549 | 3,015 |
| 2018 | 1,707 | 777 | 554 | 3,038 |
| 2019 | 1,743 | 766 | 559 | 3,067 |
| 2020 | 1,775 | 751 | 563 | 3,089 |
| 2021 | 1,807 | 731 | 566 | 3,104 |
| 2022 | 1,843 | 719 | 571 | 3,132 |
| 2023 | 1,881 | 703 | 576 | 3,160 |
| 2024 | 1,921 | 686 | 581 | 3,187 |
| 2025 | 1,959 | 673 | 586 | 3,218 |
| 2026 | 1,997 | 656 | 591 | 3,244 |
| 2027 | 2,036 | 638 | 596 | 3,270 |
| 2028 | 2,076 | 619 | 601 | 3,295 |
| 2029 | 2,116 | 600 | 605 | 3,321 |
| 2030 | 2,157 | 580 | 610 | 3,347 |
| 2031 | 2,199 | 559 | 615 | 3,373 |
| 2032 | 2,242 | 537 | 619 | 3,399 |
| 2033 | 2,286 | 515 | 624 | 3,425 |
| 2034 | 2,330 | 491 | 629 | 3,450 |
| 2035 | 2,376 | 467 | 634 | 3,476 |
| 2036 | 2,422 | 442 | 638 | 3,502 |

* Excludes NRLM fuel demand in California

Table 8.7-14
Marine Volumes Under the Proposed NRLM Fuel Program With the Shift of Downgrade to the Heating Oil Market (million gallons) *

| Year | Downgrade | New 500 ppm Fuel | Spillover | Total Volume |
|---|---|---|---|---|
| 2012 | 446 | 1,333 | 280 | 2,059 |
| 2013 | 456 | 1,338 | 283 | 2,078 |
| 2014 | 451 | 1,369 | 281 | 2,103 |
| 2015 | 436 | 1,409 | 280 | 2,126 |
| 2016 | 445 | 1,419 | 283 | 2,146 |
| 2017 | 453 | 1,431 | 286 | 2,170 |
| 2018 | 462 | 1,451 | 290 | 2,203 |
| 2019 | 471 | 1,473 | 295 | 2,240 |
| 2020 | 480 | 1,488 | 299 | 2,266 |
| 2021 | 489 | 1,503 | 302 | 2,294 |
| 2022 | 498 | 1,526 | 307 | 2,331 |
| 2023 | 509 | 1,538 | 311 | 2,357 |
| 2024 | 519 | 1,555 | 315 | 2,389 |
| 2025 | 530 | 1,568 | 319 | 2,417 |
| 2026 | 540 | 1,585 | 323 | 2,448 |
| 2027 | 551 | 1,602 | 327 | 2,479 |
| 2028 | 561 | 1,618 | 331 | 2,510 |
| 2029 | 572 | 1,634 | 335 | 2,542 |
| 2030 | 583 | 1,650 | 339 | 2,573 |
| 2031 | 595 | 1,666 | 343 | 2,604 |
| 2032 | 606 | 1,682 | 347 | 2,635 |
| 2033 | 618 | 1,697 | 352 | 2,667 |
| 2034 | 630 | 1,712 | 356 | 2,698 |
| 2035 | 642 | 1,727 | 360 | 2,729 |
| 2036 | 655 | 1,742 | 364 | 2,760 |

* Excludes NRLM fuel demand in California

Annual estimates of downgrade, spillover, small refiner fuel, and 15 and 500 ppm production volumes under the final NRLM fuel program in years other than 2014 were estimated from the estimates for 2014 in the same manner. The only difference is a new set of 2014 estimates. The 2014 estimates of downgrade, spillover, small refiner fuel, and total demand for NRLM fuel for mid-2012 to mid-2014 were taken from Table 7.1.3-19. The 2014 estimates of downgrade, spillover, small refiner fuel, and total demand for NRLM fuel for 2015 and beyond were taken from Table 7.1.3-20. The resulting estimates of downgrade, spillover, small refiner fuel, and 15 and 500 ppm production volumes for nonroad, locomotive and marine diesel fuel for the proposed rule program are summarized in Tables 8.7-15, 8.7-16 and 8.7-17, respectively.

Table 8.7-15
Nonroad Fuel Supply Under the Final Rule Fuel Program With the Shift of Downgrade to the Heating Oil Market (million gallons) *

| Year | Downgrade | Small Refiner Fuel | Spillover | New 15 ppm Fuel | Total Volume |
|---|---|---|---|---|---|
| 2012 | 1,061 | 528 | 2,760 | 8,426 | 12,774 |
| 2013 | 1,085 | 468 | 2,818 | 8,674 | 13,045 |
| 2014 | 463 | 199 | 2,941 | 9,713 | 13,316 |
| 2015 | - | - | 3,047 | 10,539 | 13,586 |
| 2016 | - | - | 3,107 | 10,747 | 13,854 |
| 2017 | - | - | 3,167 | 10,955 | 14,122 |
| 2018 | - | - | 3,227 | 11,162 | 14,390 |
| 2019 | - | - | 3,288 | 11,370 | 14,658 |
| 2020 | - | - | 3,352 | 11,578 | 14,926 |
| 2021 | - | - | 3,408 | 11,786 | 15,193 |
| 2022 | - | - | 3,468 | 11,993 | 15,461 |
| 2023 | - | - | 3,528 | 12,201 | 15,729 |
| 2024 | - | - | 3,588 | 12,409 | 15,997 |
| 2025 | - | - | 3,648 | 12,616 | 16,265 |
| 2026 | - | - | 3,708 | 12,823 | 16,531 |
| 2027 | - | - | 3,767 | 13,029 | 16,797 |
| 2028 | - | - | 3,827 | 13,236 | 17,063 |
| 2029 | - | - | 3,887 | 13,443 | 17,329 |
| 2030 | - | - | 3,946 | 13,649 | 17,595 |
| 2031 | - | - | 4,006 | 13,855 | 17,861 |
| 2032 | - | - | 4,066 | 14,062 | 18,127 |
| 2033 | - | - | 4,125 | 14,268 | 18,393 |
| 2034 | - | - | 4,185 | 14,474 | 18,659 |
| 2035 | - | - | 4,245 | 14,681 | 18,925 |
| 2036 | - | - | 4,304 | 14,887 | 19,191 |

* Excludes NRLM fuel demand in California

Table 8.7-16
Locomotive Fuel Supply Under the Final Rule Fuel Program With the Shift of Downgrade to the Heating Oil Market (million gallons) *

| Year | Downgrade | Small Refiner Fuel | Spillover | New 15 ppm Fuel | Total Volume |
|---|---|---|---|---|---|
| 2012 | 397 | 761 | 602 | 1,127 | 2,841 |
| 2013 | 274 | 99 | 607 | 1,930 | 2,909 |
| 2014 | 849 | 42 | 589 | 1,476 | 2,932 |
| 2015 | 1,281 | - | 577 | 1,099 | 2,956 |
| 2016 | 1,304 | - | 583 | 1,100 | 2,988 |
| 2017 | 1,329 | - | 589 | 1,098 | 3,015 |
| 2018 | 1,355 | - | 593 | 1,090 | 3,038 |
| 2019 | 1,383 | - | 599 | 1,086 | 3,067 |
| 2020 | 1,408 | - | 603 | 1,069 | 3,089 |
| 2021 | 1,434 | - | 606 | 1,053 | 3,104 |
| 2022 | 1,462 | - | 611 | 1,058 | 3,132 |
| 2023 | 1,492 | - | 617 | 1,051 | 3,160 |
| 2024 | 1,524 | - | 622 | 1,041 | 3,187 |
| 2025 | 1,554 | - | 628 | 1,035 | 3,218 |
| 2026 | 1,585 | - | 633 | 1,026 | 3,244 |
| 2027 | 1,616 | - | 638 | 1,016 | 3,270 |
| 2028 | 1,647 | - | 643 | 1,005 | 3,295 |
| 2029 | 1,679 | - | 648 | 994 | 3,321 |
| 2030 | 1,712 | - | 653 | 982 | 3,347 |
| 2031 | 1,745 | - | 658 | 969 | 3,373 |
| 2032 | 1,779 | - | 663 | 956 | 3,399 |
| 2033 | 1,814 | - | 668 | 942 | 3,425 |
| 2034 | 1,849 | - | 674 | 928 | 3,450 |
| 2035 | 1,885 | - | 679 | 912 | 3,476 |
| 2036 | 1,922 | - | 684 | 897 | 3,502 |

* Excludes NRLM fuel demand in California

Table 8.7-17
Marine Fuel Supply Under the Final Rule Fuel Program With the Shift of Downgrade to the Heating Oil Market (million gallons) *

| Year | Downgrade | Small Refiner Fuel | Spillover | New 15 ppm Fuel | Total Volume |
|---|---|---|---|---|---|
| 2012 | 285 | 636 | 280 | 874 | 2,059 |
| 2013 | 173 | 148 | 283 | 1,474 | 2,078 |
| 2014 | 155 | 62 | 281 | 1,605 | 2,103 |
| 2015 | 141 | - | 280 | 1,705 | 2,126 |
| 2016 | 143 | - | 283 | 1,720 | 2,146 |
| 2017 | 146 | - | 286 | 1,738 | 2,170 |
| 2018 | 149 | - | 290 | 1,763 | 2,203 |
| 2019 | 152 | - | 295 | 1,793 | 2,240 |
| 2020 | 155 | - | 299 | 1,813 | 2,266 |
| 2021 | 158 | - | 302 | 1,834 | 2,294 |
| 2022 | 161 | - | 307 | 1,863 | 2,331 |
| 2023 | 164 | - | 311 | 1,883 | 2,357 |
| 2024 | 168 | - | 315 | 1,906 | 2,389 |
| 2025 | 171 | - | 319 | 1,927 | 2,417 |
| 2026 | 174 | - | 323 | 1,951 | 2,448 |
| 2027 | 178 | - | 327 | 1,975 | 2,479 |
| 2028 | 181 | - | 331 | 1,998 | 2,510 |
| 2029 | 185 | - | 335 | 2,022 | 2,542 |
| 2030 | 188 | - | 339 | 2,046 | 2,573 |
| 2031 | 192 | - | 343 | 2,069 | 2,604 |
| 2032 | 196 | - | 347 | 2,092 | 2,635 |
| 2033 | 199 | - | 352 | 2,116 | 2,667 |
| 2034 | 203 | - | 356 | 2,139 | 2,698 |
| 2035 | 207 | - | 360 | 2,162 | 2,729 |
| 2036 | 211 | - | 364 | 2,185 | 2,760 |

* Excludes NRLM fuel demand in California

The cost of supplying NRLM fuel under the final NRLM program and for the proposed NRLM program are developed in Chapter 7 and summarized in Table 7.5-1. The engine maintenance savings associated with reduced sulfur contents are developed in Chapter 6 and summarized in Table 6.2-29. We assume that the per gallon costs developed for 2014 apply through 2036. With the increase in downgrade volume, the cost of reprocessing downgrade which occurs in some regions would increase. However, this increase occurs both with and without the 15 ppm L&M fuel cap. Thus, we did not update the estimated cost of reprocessing downgrade. The per gallon costs and savings under both L&M fuel caps are summarized here in Table 8.7-18.

Table 8.7-18
Total Diesel Fuel Costs Under 500 and 15 ppm L&M Fuel Caps*

| | Refining Cost | Additive and Distribution Cost | Maintenance Savings | Total w/o Maintenance Savings | Total with Maintenance Savings |
|---|---|---|---|---|---|
| Final NRLM Fuel Program | | | | | |
| 2012-2014 | | | | | |
| 15 ppm Nonroad | 5.6 | 0.8 | -3.2 | 6.4 | 3.2 |
| Small Refiner 500 ppm Nonroad | 2.9 | 0.2 | -2.9 | 3.1 | 0.2 |
| Small Refiner 500 ppm L&M | 2.9 | 0.2 | -1 | 3.1 | 2.1 |
| 2014 + | | | | | |
| 15 ppm Nonroad | 5.8 | 1.2 | -3.2 | 7 | 3.8 |
| 15 ppm L&M | 5.8 | 1.2 | -1.1 | 7 | 5.9 |
| 500 ppm NRLM Fuel Cap in 2007 and 15 ppm Nonroad Fuel Cap in 2010 (proposed rule program) | | | | | |
| 2012-2014 | | | | | |
| 15 ppm Nonroad | 5 | 0.8 | -3.2 | 5.8 | 2.6 |
| Small Refiner 500 ppm Nonroad | 2.7 | 0.2 | -2.9 | 2.9 | 0 |
| 500 ppm L&M | 2.7 | 0.3 | -1.0 | 3 | 2.0 |
| 2014 + | | | | | |
| 15 ppm NR | 5.2 | 1.2 | -3.2 | 6.4 | 3.2 |
| 500 ppm L&M | 2.7 | 0.2 | -1.0 | 2.9 | 1.9 |

* Fuel costs are relative to uncontrolled fuel and assume that, during the transitional years of 2012 & 2014, the first 5 months are at the previous year's cost and the remaining 7 months are at the next year's cost.

We then multiplied the production volume of each fuel in a given calendar year by the net cost of using that fuel from Table 8.7-18. For this incremental analysis, we only present estimated annual costs including the maintenance savings because, on the increment, these maintenance savings are minor (0.1 c/gal) compared to the incremental cost of producing 15 ppm L&M fuel. Little information would be gained from presenting costs without the maintenance savings, as is done for the final rule analysis and the other sensitivity cases. We do present the final discounted costs without the maintenance savings, as well as the cost-effectiveness based on the costs without maintenance savings, in Table 8.7-24. The resulting annual costs are shown in Table 8.7-19.

Table 8.7-19
Annual Fuel Costs & Oil Change Maintenance Savings With the Shift of Downgrade to the Heating Oil Market ($2002 million)

| Year | Final NRLM Fuel Program | 15 ppm NR Cap and 500 ppm L&M Cap | 15 ppm L&M Incremental Costs |
|---|---|---|---|
| 2012 | $ 268 | $ 162 | $ 107 |
| 2013 | $ 472 | $ 282 | $ 190 |
| 2014 | $ 524 | $ 337 | $ 187 |
| 2015 | $ 566 | $ 379 | $ 187 |
| 2016 | $ 575 | $ 386 | $ 189 |
| 2017 | $ 583 | $ 393 | $ 191 |
| 2018 | $ 592 | $ 400 | $ 193 |
| 2019 | $ 602 | $ 406 | $ 195 |
| 2020 | $ 610 | $ 413 | $ 197 |
| 2021 | $ 618 | $ 420 | $ 198 |
| 2022 | $ 628 | $ 426 | $ 202 |
| 2023 | $ 637 | $ 433 | $ 203 |
| 2024 | $ 645 | $ 440 | $ 206 |
| 2025 | $ 654 | $ 446 | $ 208 |
| 2026 | $ 663 | $ 453 | $ 210 |
| 2027 | $ 671 | $ 459 | $ 212 |
| 2028 | $ 680 | $ 466 | $ 214 |
| 2029 | $ 688 | $ 473 | $ 216 |
| 2030 | $ 697 | $ 479 | $ 218 |
| 2031 | $ 705 | $ 486 | $ 220 |
| 2032 | $ 714 | $ 492 | $ 222 |
| 2033 | $ 722 | $ 499 | $ 224 |
| 2034 | $ 731 | $ 505 | $ 226 |
| 2035 | $ 739 | $ 511 | $ 227 |
| 2036 | $ 747 | $ 518 | $ 229 |
| Total 30-Year Costs (2007-2036) | | | |
| Undiscounted | $ 15,731 | $ 10,664 | $ 5,068 |
| 30 Yr NPV at 3% | $ 8,640 | $ 5,829 | $ 2,811 |
| 30 Yr NPV at 7% | $ 4,249 | $ 2,847 | $ 1,402 |

The absence of the shift of downgrade to the heating oil market in the Northeast/Middle Atlantic area has no impact on the supply of NRLM fuel under the proposed NRLM fuel program. Thus, the various volumes of NRLM fuel shown in Tables 8.7-12 through 8.7-14 still apply. Without the shift of downgrade to heating oil, the production volumes of NRLM fuel under the final NRLM fuel program become very similar to those for the proposed NRLM fuel program, except that L&M fuel produced after mid-2012 would have to meet a 15 ppm cap instead of a 500 ppm cap. The volumes of spillover, downgrade and demand are identical. The only difference is that the volume of 500 ppm, small refiner fuel is slightly greater with a long-term 500 ppm L&M fuel cap than with a 15 ppm cap. Thus, the incremental volume of 15 ppm fuel from mid-2012 to mid-2014 under the 15 ppm L&M fuel cap is slightly higher than simply the volume of 500 ppm L&M fuel which must be produced under the 500 ppm L&M cap. Table 8.7-20 shows the breakdown of nonroad, locomotive and marine fuel supply for the final NRLM fuel program without a shift in downgrade to heating oil.

Table 8.7-20
NRLM Fuel Supply Under the Final NRLM Fuel Program Without a Downgrade Shift to Heating Oil (million gallons) *

| Year | Downgrade | Small Refiner Fuel | Spillover | New 15 ppm Fuel | Total Volume |
|---|---|---|---|---|---|
| | Nonroad Diesel Fuel | | | | |
| 2012 | 1,061 | 528 | 2,760 | 8,426 | 12,774 |
| 2013 | 1,085 | 468 | 2,818 | 8,674 | 13,045 |
| 2014 | 463 | 199 | 2,940 | 9,713 | 13,316 |
| 2015 + | Same as for Proposed NRLM Fuel Program | | | | |
| | Locomotive Diesel Fuel | | | | |
| 2012 | 579 | 761 | 602 | 944 | 2,886 |
| 2013 | 593 | 99 | 607 | 1610 | 2,909 |
| 2014 | 1,176 | 42 | 566 | 1148 | 2,932 |
| 2015 + | Same as for Proposed NRLM Fuel Program | | | | |
| | Marine Diesel Fuel | | | | |
| 2012 | 446 | 636 | 280 | 697 | 2,059 |
| 2013 | 456 | 148 | 283 | 1191 | 2,078 |
| 2014 | 451 | 62 | 280 | 1310 | 2,103 |
| 2015 + | Same as for Proposed NRLM Fuel Program | | | | |

* Excludes NRLM fuel demand in California

The per gallon costs shown in Table 8.7-19 are unaffected by the absence of a shift in downgrade to the heating oil market.[D] Thus, the annual costs with a 500 ppm L&M cap are the same as before. The annual costs under the final NRLM program decrease slightly, as 15 ppm L&M fuel does not need to replace downgrade shifted from the L&M market to the heating oil market in the Northeast/Middle Atlantic exclusion area. The annual costs under both programs are shown in Table 8.7-21.

[D] The reduced volume of 15 ppm L&M fuel under the final NRLM fuel program could reduce the per gallon cost of 15 ppm fuel, as those refiners facing the highest costs might be the first to avoid producing this fuel. However, as indicated by the sensitivity analysis of potentially lower nonroad fuel demand (Case 1 Sensitivity) discussed in Section 3 of Appendix 8A, significantly lowering the demand for 15 ppm NRLM fuel has little effect on the cost per gallon.

Table 8.7-21
Annual Fuel Costs & Oil Change Maintenance Savings Without Shift of Downgrade to the Heating Oil Market ($2002 million)

| Year | Final NRLM Fuel Program | Proposed NRLM Fuel Program | Incremental Cost of 15 ppm L&M Cap |
|---|---|---|---|
| 2012 | $249 | $162 | $88 |
| 2013 | $432 | $282 | $150 |
| 2014 | $488 | $337 | $151 |
| 2015 | $531 | $379 | $152 |
| 2016 | $539 | $386 | $153 |
| 2017 | $547 | $393 | $155 |
| 2018 | $556 | $400 | $156 |
| 2019 | $564 | $406 | $158 |
| 2020 | $572 | $413 | $159 |
| 2021 | $580 | $420 | $160 |
| 2022 | $588 | $427 | $162 |
| 2023 | $596 | $433 | $163 |
| 2024 | $604 | $440 | $164 |
| 2025 | $612 | $446 | $165 |
| 2026 | $619 | $453 | $166 |
| 2027 | $627 | $460 | $168 |
| 2028 | $635 | $466 | $169 |
| 2029 | $643 | $473 | $170 |
| 2030 | $650 | $479 | $171 |
| 2031 | $658 | $486 | $172 |
| 2032 | $665 | $492 | $173 |
| 2033 | $673 | $499 | $174 |
| 2034 | $680 | $505 | $175 |
| 2035 | $687 | $512 | $176 |
| 2036 | $695 | $518 | $177 |
| Total 30-Year Costs (2007 - 2036) | | | |
| Undiscounted | $14,690 | $10,665 | $4,025 |
| 30-Year NPV at 3% | $8,070 | $5,830 | $2,240 |
| 30-Year NPV at 7% | $3,969 | $2,847 | $1,121 |

Moving to emission reductions, we used the methodology used in the draft 2004 NONROAD model to estimate $SO_2$ and sulfate PM emissions from NRLM engines (Section 3.1 of the Final RIA). To calculate the emission reductions, we needed estimates for the sulfur levels for nonroad, locomotive and marine diesel fuel.

In Section 7.1.6 of the Final RIA, we present our estimate of the sulfur levels of on-purpose produced diesel fuel, spillover, and downgrade. These sulfur levels, spillover (11 ppm), small refiner fuel (340 ppm), and non-small refiner fuel (either 340 or 11 ppm), are unaffected by changing the volume of downgrade projected to be generated during fuel distribution. For downgrade, in Section 7.1, we estimated that jet-based downgrade contained 400-470 ppm sulfur and highway-based downgrade contained 25-35 ppm sulfur. The relative volumes of these downgrades varies by region. We calculated a national average sulfur content for combined highway-based and jet-based downgrade used in the L&M markets by weighting the sulfur contents of each downgrade type in each region. The result was an average downgrade sulfur content of 101 ppm for the proposed NRLM program and 172 ppm for the final NRLM program. These sulfur levels were used for downgrade volumes for all the years of the incremental analysis.[E] We also applied these downgrade sulfur contents to the small volume of downgrade used in the nonroad fuel market from mid-2012 to mid-2014. The resulting overall sulfur levels for NRLM fuel are summarized in Table 8.7-22.

[E] The downgrade comprised of highway diesel fuel and jet fuel likely changes in sulfur level throughout the period as the relative volume of highway and jet fuel varies relative to each other. However, the growth of highway diesel fuel and jet fuel is very similar so very little change is expected throughout the analysis period. Thus, this assumption seems reasonable.

Table 8.7-22
Sulfur Levels of NRLM Diesel Fuel Based on Revised Downgrade Estimates (million gallons)

| | 48 State Analysis | | | | 50 State Analysis | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Proposed Rule | | Final Rule | | Proposed Rule | | Final Rule | |
| | NR | L&M | NR | L&M | NR | L&M | NR | L&M |
| 2012 | 36 | 236 | 32 | 122 | 36 | 237 | 33 | 125 |
| 2013 | 36 | 235 | 29 | 43 | 36 | 237 | 30 | 47 |
| 2014 | 21 | 215 | 19 | 49 | 22 | 214 | 19 | 51 |
| 2015 | 11 | 201 | 11 | 55 | 11 | 198 | 11 | 54 |
| 2016 | 11 | 200 | 11 | 55 | 11 | 197 | 11 | 54 |
| 2017 | 11 | 199 | 11 | 55 | 11 | 196 | 11 | 54 |
| 2018 | 11 | 198 | 11 | 56 | 11 | 195 | 11 | 55 |
| 2019 | 11 | 198 | 11 | 56 | 11 | 194 | 11 | 55 |
| 2020 | 11 | 197 | 11 | 56 | 11 | 194 | 11 | 55 |
| 2021 | 11 | 195 | 11 | 57 | 11 | 192 | 11 | 56 |
| 2022 | 11 | 193 | 11 | 57 | 11 | 190 | 11 | 56 |
| 2023 | 11 | 192 | 11 | 57 | 11 | 189 | 11 | 57 |
| 2024 | 11 | 191 | 11 | 58 | 11 | 188 | 11 | 57 |
| 2025 | 11 | 190 | 11 | 58 | 11 | 187 | 11 | 57 |
| 2026 | 11 | 189 | 11 | 59 | 11 | 186 | 11 | 58 |
| 2027 | 11 | 188 | 11 | 59 | 11 | 185 | 11 | 58 |
| 2028 | 11 | 187 | 11 | 59 | 11 | 184 | 11 | 59 |
| 2029 | 11 | 187 | 11 | 60 | 11 | 183 | 11 | 59 |
| 2030 | 11 | 186 | 11 | 60 | 11 | 182 | 11 | 59 |
| 2031 | 11 | 185 | 11 | 61 | 11 | 181 | 11 | 60 |
| 2032 | 11 | 184 | 11 | 61 | 11 | 180 | 11 | 60 |
| 2033 | 11 | 183 | 11 | 62 | 11 | 179 | 11 | 61 |
| 2034 | 11 | 181 | 11 | 62 | 11 | 178 | 11 | 61 |
| 2035 | 11 | 180 | 11 | 62 | 11 | 177 | 11 | 62 |
| 2036 | 11 | 179 | 11 | 63 | 11 | 176 | 11 | 62 |
| 2037 | 11 | 178 | 11 | 63 | 11 | 175 | 11 | 62 |
| 2038 | 11 | 177 | 11 | 64 | 11 | 174 | 11 | 63 |
| 2039 | 11 | 176 | 11 | 64 | 11 | 173 | 11 | 63 |
| 2040 | 11 | 175 | 11 | 65 | 11 | 171 | 11 | 64 |

We developed these for 50-state and 48-state regions, as this was done for the other alternatives evaluated in Chapter 3. We use the 50-state sulfur levels here, even though the volumes developed above are for the U.S. excluding California. Thus, the total sulfur dioxide and sulfate PM emissions resulting from combining the fuel volumes with the sulfur contents are not correct. However, as the 15 ppm L&M cap has no impact on sulfur levels in California, the difference in sulfurous emissions between the two L&M fuel caps is correct. To avoid any possible mis-use of the absolute emissions under either L&M cap, we only present the differential emission estimates below.

In Section 7.1.6, we also estimate the sulfur content of heating oil by assuming that heating oil has the same sulfur content as NRLM fuel prior to the final NRLM rule. That is acceptable for the analysis of the overall NRLM rule, since the emission reductions related to changes in the sulfur content of heating oil are minor relative to emission reductions related to changes in sulfur content of NRLM. However, in analyzing the incremental step of reducing L&M fuel sulfur from 500 to 15 ppm, heating oil related emission represent a significant portion of the emission reductions and therefore warrant closer scrutiny. The impacts on the sulfur content of heating oil occur in the overall program primarily as a result of changes in where spillover and downgrade are projected to be used. With the imposition of the 15 ppm limit, downgrade product in particular is forced from other markets into the heating oil market. When this downgraded distillate cannot be used in NR or in L&M fuel, it will shift to the heating oil market. The main impact of this is felt as the last increment of diesel fuel, the L&M portion, is required to meet a 15 ppm limit, and primarily in the Northeast and Mid-Atlantic area where the majority of heating oil is marketed, and when under the provisions of the final rule downgraded material cannot continue to be sold into the NRLM markets. The downgrade contains between 31 (highway-based) and 435 ppm (jet-based) sulfur, well below that of heating oil. Thus, the sulfur content of heating oil decreases significantly in the Northeast/Mid-Atlantic area with a 15 ppm cap on L&M fuel.

In the Northeast and Middle Atlantic area of the U.S., certain states regulate the sulfur content of heating oil, so some of the heating oil in this area contains much less sulfur than NRLM fuel. As a result, the sulfur level estimates based on high sulfur diesel fuel may not be entirely accurate for representing the sulfur level of heating oil, particularly in this area of the country. Given that the majority of the impact on emissions from heating oil for analyzing the L&M increment to 15 ppm are in this part of the country, we looked to see what other data might be available to better assess the sulfur levels. We obtained heating oil surveys from TRW [5,6]. TRW surveys covers heating oil produced in the U.S. TRW's districts A and B match the Northeast/Mid-Atlantic area area quite closely. In 2001 and 2002, heating oil produced by refineries for this market averaged 1385 ppm sulfur. (As was described in Section 7.1.6, we exclude sulfur measurements less than 500 ppm, as these likely represent spillover from the highway fuel supply.) This is less than half that of average NRLM fuel in PADD 1 (2925 ppm, see Table 7.1.6-3).

One difficulty in using the heating oil survey results directly is that the heating oil may be marketed as a single high sulfur distillate fuel to both the diesel fuel and heating oil markets. Thus, much of the intended sales for heating oil purposes could have been used as diesel fuel. The TRW surveys for both diesel fuel and heating oil cover only a small fraction of the total volume of fuel sold in the U.S. It is not clear whether the heating oil not covered by the data submitted by refiners to TRW resembles the high sulfur diesel fuel containing roughly 2900 ppm sulfur or the heating oil containing roughly 1400 ppm sulfur. Because of this uncertainty, we assume that the average heating oil in the Northeast/Mid-Atlantic Area contains 2155 ppm sulfur, the average of the TRW survey estimates for high sulfur diesel fuel and heating oil.

With the imposition of the 15 ppm L&M standard in 2012, and because of the Northeast/Mid-Atlantic area provisions of the final NRLM fuel program, 616 million gallons of downgrade is shifted from the NRLM market to the heating oil market in 2014. Of this, 143 million gallons is jet-based downgrade and 473 million gallons is highway-based downgrade. In PADD 1, jet-based downgrade is estimated to contain 470 ppm sulfur, while highway-based downgrade contains 35 ppm sulfur. Thus, the average sulfur content of both downgrades is 129 ppm. Shifting this downgrade from the NRLM fuel market to the heating oil market reduces the sulfur content of the 616 million gallons of heating oil by 2026 ppm (2155 ppm minus 129 ppm). The volume of downgrade used in heating oil is estimated for the years before and after 2014 using the overall downgrade growth rates shown in Table 8.7-11. The resulting incremental volume of downgrade estimated to be shifted over to heating oil from 2012 to 2036 due to the final NRLM program is summarized in Table 8.7-23. The same 2026 ppm sulfur reduction due to the shift of downgrade to the heating oil pool is used for all the years.

Table 8.7-23
Incremental Volume of Downgrade Forced into Heating Oil by the Final NRLM Program
(Million gallons)

| Year | Volume |
|---|---|
| 2012 | 343 |
| 2013 | 602 |
| 2014 | 616 |
| 2015 | 628 |
| 2016 | 640 |
| 2017 | 652 |
| 2018 | 665 |
| 2019 | 679 |
| 2020 | 691 |
| 2021 | 704 |
| 2022 | 718 |
| 2023 | 732 |
| 2024 | 748 |
| 2025 | 763 |
| 2026 | 778 |
| 2027 | 793 |
| 2028 | 808 |
| 2029 | 824 |
| 2030 | 840 |
| 2031 | 856 |
| 2032 | 873 |
| 2033 | 890 |
| 2034 | 907 |
| 2035 | 925 |
| 2036 | 943 |

We estimate that 99% of the sulfur in heating oil is emitted in the form of sulfur dioxide and 1% in the form of sulfate PM.[7] Otherwise, the reductions in sulfur dioxide and sulfate PM emissions due to this shift of downgrade to the PADD 1 heating oil market were estimated using the formula described in Chapter 3.[F] Table 8.7-16 presents the annual sulfur dioxide and sulfate PM emission reductions from NRLM fuel and heating oil. The reductions in NRLM emissions represent the difference in sulfur dioxide and sulfate PM emissions under the proposed and final NRLM fuel programs. These emissions under each fuel program are derived from combining the sulfur contents shown in Table 8.7-24 for the 50-state region with the NRLM fuel demands shown in Tables 8.7-12 through 8.7-17.

[F] As described in Chapter 3, sulfur dioxide has twice the mass of sulfur contained within it. Diesel fuel and heating oil are both assumed to have a density of 7.1 pounds per gallon. Thus, the formula for calculating the sulfur dioxide emission reduction from heating oil consumption in 2014 is: 616 million gallons * 7.1 lb/gal * 2026 parts sulfur per million parts heating oil by mass * 99% conversion of sulfur to $SO_2$ * 2 lbs $SO_2$ per lb sulfur / 2000 lb/ton. Sulfate PM in the atmosphere is estimated to have 7 times the mass of the sulfur contained within it. Thus, the formula for calculating the sulfate PM emission reduction from heating oil consumption in 2014 is: 616 million gallons * 7.1 lb/gal * 2026 parts sulfur per million parts heating oil by mass * 1% conversion of sulfur to sulfate PM * 7 lbs sulfate PM per lb sulfur / 2000 lb/ton.

Table 8.7-24
Annual Sulfur Dioxide and Sulfate PM Emission Reductions: 15 ppm Versus 500 ppm L&M Cap (tons per year)

| Year | Sulfur Dioxide | | | Sulfate PM | | |
|---|---|---|---|---|---|---|
| | NRLM Fuel | Heating Oil | Total | NRLM Fuel | Heating Oil | Total |
| 2012 | 4,305 | 4,884 | 9,189 | 372 | 173 | 545 |
| 2013 | 7,450 | 8,572 | 16,022 | 709 | 303 | 1012 |
| 2014 | 6,264 | 8,772 | 15,036 | 580 | 310 | 890 |
| 2015 | 5,319 | 8,944 | 14,263 | 415 | 316 | 731 |
| 2016 | 5,332 | 9,108 | 14,440 | 416 | 322 | 738 |
| 2017 | 5,342 | 9,276 | 14,618 | 417 | 328 | 745 |
| 2018 | 5,353 | 9,453 | 14,806 | 418 | 334 | 752 |
| 2019 | 5,381 | 9,649 | 15,030 | 420 | 341 | 761 |
| 2020 | 5,385 | 9,822 | 15,207 | 420 | 347 | 767 |
| 2021 | 5,346 | 9,999 | 15,345 | 417 | 354 | 771 |
| 2022 | 5,327 | 10,195 | 15,522 | 416 | 360 | 776 |
| 2023 | 5,309 | 10,404 | 15,713 | 414 | 368 | 782 |
| 2024 | 5,310 | 10,627 | 15,937 | 414 | 376 | 790 |
| 2025 | 5,310 | 10,836 | 16,146 | 414 | 383 | 797 |
| 2026 | 5,309 | 11,046 | 16,355 | 414 | 391 | 805 |
| 2027 | 5,311 | 11,261 | 16,572 | 414 | 398 | 812 |
| 2028 | 5,305 | 11,479 | 16,784 | 414 | 406 | 820 |
| 2029 | 5,300 | 11,702 | 17,002 | 414 | 414 | 828 |
| 2030 | 5,294 | 11,929 | 17,223 | 413 | 422 | 835 |
| 2031 | 5,283 | 12,160 | 17,443 | 412 | 430 | 842 |
| 2032 | 5,274 | 12,396 | 17,670 | 412 | 438 | 850 |
| 2033 | 5,258 | 12,637 | 17,895 | 410 | 447 | 857 |
| 2034 | 5,245 | 12,882 | 18,127 | 409 | 455 | 864 |
| 2035 | 5,226 | 13,132 | 18,358 | 408 | 464 | 872 |
| 2036 | 5,209 | 13,387 | 18,596 | 407 | 473 | 880 |
| 30-Year (2007-2036) Emission Reduction | | | | | | |
| Undiscounted | 134,700 | 264,600 | 399,300 | 10,760 | 9,350 | 20,100 |
| 30 Yr NPV at 3% | 76,800 | 144,600 | 221,400 | 6,180 | 5,110 | 11,300 |
| 30 Yr NPV at 7% | 39,700 | 70,800 | 110,500 | 3,230 | 2,500 | 5,730 |

If no shift in downgrade to heating oil is assumed, the sulfur dioxide and sulfate PM emission reductions due to the 15 ppm L&M fuel cap are simply the differences in the emissions in the two columns of Table 8.7-24 labeled NRLM fuel.[G]

The 30-year cost effectiveness of the 15 ppm L&M cap is the ratio of the 30-year costs shown in Tables 8.7-19 and 8.7-21 divided by the 30-year emission reductions of sulfur dioxide and sulfate PM shown in Table 8.7-24. We have allocated 67 percent of the costs to sulfur dioxide emission control and 33 percent to sulfate PM control consistent with our allocation of

[G] We ignored the small change in L&M fuel sulfur content which would occur if the downgrade remained in the L&M market.

costs associated with fuel-derived benefits throughout our analysis. The results are presented in Table 8.7-25.

Table 8.7-25
Incremental Cost Effectiveness of the 15 ppm L&M Fuel Sulfur Cap
30-year Net Present Values at a 3% Discount Rate ($2002)

| | 3% Discount Rate | | 7% Discount Rate | |
|---|---|---|---|---|
| | SOx | PM | SOx | PM |
| With Shift of Downgrade to Heating Oil | | | | |
| Cost ($ million) | $ 1,870 | $ 940 | $ 935 | $ 467 |
| Emissions Reduction (tons) | 221,400 | 11,300 | 110,500 | 5,730 |
| Cost per ton ($/ton) | $ 8,450 | $ 83,200 | $ 8,460 | $ 81,500 |
| Without Shift of Downgrade to Heating Oil | | | | |
| Cost ($ million) | $1,493 | $747 | $747 | $374 |
| Emissions Reduction (tons) | 76,800 | 6,180 | 39,700 | 3,230 |
| Cost per ton ($/ton) | $ 19,400 | $ 120,700 | $ 18,800 | $ 115,800 |

As can be seen, the incremental cost effectiveness of the 15 ppm L&M fuel cap worsens without the shift in downgrade to the heating oil market. This indicates that the cost effectiveness of shifting downgrade from the L&M market to the heating oil market and replacing it with 15 ppm L&M fuel is more cost effective than simply reducing L&M fuel sulfur from 500 ppm to 15 ppm. The shift in downgrade itself is environmentally neutral from sulfur perspective, since all of the sulfur is emitted regardless of whether it is burned in a locomotive or marine diesel engine or a furnace or stationary diesel engine. The conversion of sulfur to PM is less for heating oil, but as the majority of the sulfur is emitted as sulfur dioxide in either case, sulfur dioxide emissions are the same. The difference is that, with the downgrade shift to heating oil, the new 15 ppm L&M fuel replaces high sulfur heating oil. Without the shift, the new 15 ppm L&M fuel replaces 500 ppm L&M fuel. The cost of producing 15 ppm L&M fuel from high sulfur fuel are higher than from 500 ppm fuel, 8.3 cents per gallon versus 3.1 cents per gallon. However, the sulfur reduction is also higher and to a much greater degree. With heating oil at 2155 ppm, the in-use reduction is 2144 ppm, while that from 500 ppm L&M fuel is only 329 ppm. Thus, the sulfur benefits are a factor of seven time higher, while costs are less than a factor of three higher.

While we evaluate the incremental cost effectiveness of the 15 ppm L&M cap with and without the shift of downgrade to the heating oil market, we believe that the former is the most appropriate way to evaluate this fuel control step as it is consistent with the design of the program which reflects the characteristics of the distribution system. The prohibition on using downgrade in the NRLM markets in the Northeast/Middle Atlantic area eliminates the marking of the significant volume of heating oil in this area beginning in 2007. This is an important and valuable aspect of the final NRLM fuel program which was made regardless of any decision to control L&M fuel to 15 ppm. Thus, it is appropriate to include the effect of this provision on the cost effectiveness of 15 ppm L&M fuel control.

### 8.7.4 Costs per Ton Summary

Table 8.7-26 presents a summary of the cost per ton calculations presented in Sections 8.7.1 through 8.7.4.

As noted in section 8.1, we have allocated costs slightly differently in the final analysis than we did in the proposed analysis.[H] Table 8.7-27 presents the costs per ton using the allocations used in the proposal. To clarify, Table 8.7-27 does not present the costs per ton from the proposed analysis. Instead, the values presented in Table 8.7-27 are the costs per ton using the final rule's costs and emissions reductions but allocating the costs using the method used in the proposal. As such, Table 8.7-27 provides a comparison of how the new cost allocations affect the costs per ton and does not provide a comparison of the final costs per ton to the proposed costs per ton.

[H] The cost allocations used in the proposal differed slightly in that costs associated with fuel-derived benefits were allocated entirely to SOx (FRM allocations split them one-third to PM and two-thirds to SOx) and costs of 15 ppm fuel were allocated entirely to engine-derived benefits (FRM allocations split them one-half to fuel-derived benefits and one-half to engine-derived benefits).

Table 8.7-26
Summary of Costs and Cost per Ton Estimates based on 30 Year NPVs
($2002)

| **NRT4 Full Program** | 3% discount rate | 7% discount rate |
|---|---|---|
| NPV of Total Cost ($millions) | $ 27,100 | $ 13,800 |
| $/ton PM | $ 11,200 | $ 11,800 |
| $/ton NOx+NMHC | $ 1,010 | $ 1,160 |
| $/ton SOx | $ 690 | $ 620 |
| **15ppm NRLM Fuel-only Scenario** | | |
| NPV of Total Cost w/ Savings ($millions) | $ 9,200 | $ 4,600 |
| NPV of Total Cost w/o Savings ($millions) | $ 16,300 | $ 8,500 |
| $/ton PM w/ Savings | $ 6,600 | $ 6,000 |
| $/ton PM w/o Savings | $ 11,800 | $ 11,200 |
| $/ton SOx w/ Savings | $ 1,070 | $ 970 |
| $/ton SOx w/o Savings | $ 1,900 | $ 1,800 |
| **500ppm NRLM Fuel-only Scenario** | | |
| NPV of Total Cost w/ Savings ($millions) | $ (500) | $ (300) |
| NPV of Total Cost w/o Savings ($millions) | $ 5,400 | $ 3,000 |
| $/ton PM w/ Savings | $ (400) | $ (400) |
| $/ton PM w/o Savings | $ 4,300 | $ 4,300 |
| $/ton SOx w/ Savings | $ (70) | $ (70) |
| $/ton SOx w/o Savings | $ 690 | $ 700 |
| **15 ppm L&M Fuel-only Scenario (Increment) *** | | |
| NPV of Incremental Cost w/ Savings ($millions) | $ 2,810 | $ 1,400 |
| $/ton PM w/ Savings (incremental) | $ 83,200 | $ 81,500 |
| $/ton SOx w/ Savings (incremental) | $ 8,450 | $ 8,460 |

* Includes shift of downgrade to heating oil in the Northeast/Middle Atlantic area

Table 8.7-27
Costs and Costs per Ton of the NRT4 Full Program
using the Proposal's Cost Allocations
30 Year NPVs using a 3% Discount Rate ($2002)

| **NRT4 Full Program** | 3% discount rate |
|---|---|
| NPV of Total Cost ($millions) | $ 27,100 |
| $/ton PM | $ 11,000 |
| $/ton NOx+NMHC | $ 1,250 |
| $/ton SOx | $ 460 |

# Appendix 8A: Estimated Aggregate Cost and Cost per Ton of Sensitivity Analyses

## 8A.1 What Sensitivity Analyses Have Been Performed?

This Appendix contains two sensitivity analyses EPA performed regarding the emissions inventory predictions from the NONROAD model, as well as cost and cost per ton analysis which correspond to these two NONROAD model sensitivities. In the NONROAD model sensitivity Case 1, we have adjusted the emissions predictions so that NONROAD's fuel consumption estimates match the predictions of fuel volume from the Energy Information Agency. In the NONROAD model sensitivity Case 2, we have increased the fraction of diesel generators sold in the U.S. which are considered "mobile" (and therefore decreased the percentage which are "stationary") and we have increased the annual hours of use for several categories of nonroad equipment in the >750 hp category.

In the remainder of section 8A.1, we describe why we have included these sensitivity analyses in the final rule. In section 8A.2, we describe what changes were made to the NONROAD model, how each of the sensitivities were performed, and the emission inventory impacts of Case 1 and Case 2. In section 8A.3, we describe how we have altered our engine and fuel program cost methodology to match Case 1 and Case 2, what the resulting program cost estimates are using Case 1 and Case 2, and finally what the cost-per-ton estimates are for Case 1 and Case 2. In section 8A.4, we summarize the results presented in sections 8A.1 through 8A.3.

### 8A.1.1 What is the Case 1 Sensitivity Analysis?

The Case 1 sensitivity analysis results from comments we received on the proposal which suggested that the NONROAD model over-predicts the growth rate of the nonroad fleet. The commenters suggested that the NONROAD model's growth rates should be adjusted downward so that overall fuel consumption matches the predictions made by the Department of Energy's Energy Information Agency (EIA). As described in detail in the Summary and Analysis of Comments for this rule, we disagree with these comments and we have not made a change to the NONROAD model as a result of these comments (see section 2.3.2.2.3 of the Summary and Analysis of Comments document for this final rule). However, we are performing a sensitivity analysis (Case 1) which estimates what the impact of such a change would have on our estimates of the emissions reduction of this rule, the costs of this rule, and our cost-per-ton estimates.

### 8A.1.2 What is the Case 2 Sensitivity Analysis?

The Case 2 sensitivity analysis results from information we received during the development of the rule on two issues which indicates NONROAD is under-predicting emissions from some nonroad engines. One of these issues is the partitioning of generator sets into mobile and stationary. The second issue is the annual hours of use estimates for large engines (those >750 hp).

### 8A.1.2.1 Information Regarding Mobile & Stationary Generator Sets

During our discussions with several engine manufacturers who produce the >750 hp diesel engines, three manufacturers (who together represent a majority of the market), provided EPA with recent year sales estimates of engines used in mobile machines in the >750 hp category (e.g., mining trucks, dozers, wheel loaders, etc.) and generator sets. These manufacturers produce engines for generator sets which are certified to the existing Tier 1 nonroad standards, as well as engines which are not certified to the nonroad standards because the engines are designed for stationary power generation and therefore are not subject to EPA's nonroad standards. Many of the >750 hp nonroad certified engines which are used in generator sets are used in applications such as the large portable power generators that are contained in a Class 8 truck trailer, where power generation ratings of 1, 1.5 and 2 megawatts are common. These products are designed to be portable and are used by rental companies and in other industries where large amounts of power are needed for a relatively short duration of time. The data from the engine manufacturers indicates that approximately 30 percent of the >750 hp diesel generator sets sold in the U.S. are portable and subject to EPA nonroad diesel standards. In addition, manufacturers build some stationary engines to nonroad certified configurations to simplify their product base and thus the nonroad engine standards yield an added indirect, yet real, emission benefit.

The data which is used to estimate the nonroad equipment population in NONROAD comes from the PSR database. This database does not distinguish between mobile and stationary diesel generator sets. As documented in EPA report EPA420-P-02-004, we estimate for all of the diesel generators what percent of the PSR database diesel generator sets are mobile (and therefore subject to the EPA's nonroad standards) and what percent is stationary. These estimates vary by power range, with the percent that are considered stationary increasing with increasing rated power. For example, for <25 hp engines we estimate 10 percent are stationary, and for >600 hp, we estimate that 100 percent are stationary. Once these percentages are applied to the PSR database data to remove the estimated stationary generator sets, the remaining generator set data is used to estimate the population of generator sets in NONROAD.

The recent information we received from the engine manufacturers (~ 30 percent of generator sets >750 hp are mobile/portable) is substantially different from the current assumptions which go into NONROAD (no generators >600 hp are mobile/portable). Because at this time we do not have reference-able industry-wide information on this issue, we have not performed a new analysis to update NONROAD. However, it is clear that the recent confidential information from the engine companies indicates NONROAD is underestimating the number of nonroad diesel generators. As discussed in Chapter 8A.2, we have performed a sensitivity analysis which includes a higher percentage of mobile diesel generator sets based on the information we received from the engine manufacturers.

### 8A.1.2.2 Information Regarding Usage Factors for >750hp Mobile Machines and Generators

As discussed in the preamble for this final rule, we have recognized some of the unique features of the >750 hp mobile machines. Most of the >750 hp engines used in the mobile machine category are used in mining applications, such as mining trucks, dozers, excavators and loaders. As part of our feasibility analysis, we spent a considerable amount of time with a number of engine manufacturers and equipment manufacturers to understand the applications these large engines are used in. In addition, several manufacturers provided EPA with data regarding the >750 hp mobile machine applications. One of the pieces of data which we noticed was the high annual hours of use for this equipment, which in some cases was greater than 4,000 hours per year. During our discussions with both engine and equipment manufacturers, companies made the point these large pieces of equipment are very expensive (in excess of $1 million), and that mining operations are often run 7 days a week, “around the clock”. Because of these two factors, the large mobile machines are operated at higher annual usage rates than most nonroad applications.

While we received this type of information from multiple companies, the most convincing data we received came from one of the industry’s larger equipment companies. This equipment company provided EPA with confidential data for mobile machines >750 hp which included sales and annual hours of use estimates. The equipment types covered by the data included applications such as off-highway trucks, dozers, wheel loaders, and off-highway tractors. The data was representative of 10 years worth of sales, and several thousand pieces of equipment. On average, the manufacturer estimated the annual hours of use for this equipment was > 3,500 hours per year. We also received information from several engine and equipment companies which indicates the annual hours of use for >750 portable generator sets are on the order of 1,000 hours per year.

The NONROAD model contains estimates of annual hours of use which are used in the process of estimating annual emissions. The annual hours of use values are documented in EPA report EPA420-P-02-014. The annual hours of use do not vary by power category, therefore the estimate for a 250 hp dozer is the same as the estimate for a 1,000 hp dozer. For the >750 hp applications on which we received new data, the highest annual hours of use value in NONROAD is 1,641 hours/year for off-highway trucks, and for generator sets the value is 338 hours/year. These values are substantially lower than the usage information we received from engine and equipment manufacturers. While we now believe NONROAD underestimates the emissions impact of the >750hp equipment based on the new information we have received, we have not changed NONROAD at this time. The information we received, though useful for this sensitivity analysis, is not adequately reference-able and may not be sufficiently representative. In addition, while we believe it is directionally correct, we have not had an opportunity to independently verify the information or collect additional data from other sources. As a result, though not reflected in the NONROAD model results for this final rule, the Case 2 sensitivity analysis does include higher annual hours of use values for several categories of mobile machines >750hp and for generator sets >750hp, which is based on the information we received from engine and equipment companies.

## 8A.2 What Emissions Modeling was Done?

### 8A.2.1 Case 1: Inventories Adjusted to Match Fuel Consumption Derived from EIA Sources

To represent the emissions inventory for Case 1, we did not perform additional NONROAD runs. Rather, we adjusted the NONROAD fuel consumption and emissions estimates so that estimated fuel consumption matched fuel consumption estimates derived from EIA sources. We performed the adjustment by applying ratios to the NONROAD fuel consumption and emissions outputs. Specifically,, we calculated an adjustment ratio *r* as

$$r_y = \frac{F_{\mathrm{NONROAD},y}}{F_{\mathrm{EIA},y}}$$

where $F_{\mathrm{NONROAD},y}$ is a national fuel consumption estimate as generated by Draft NONROAD2004 for year *y*, and $F_{\mathrm{EIA},y}$ is a corresponding estimate derived from EIA's *Annual Energy Outlook 2003* (AEO 2003). These reports provide distillate fuel consumption projections by economic sector.

The derivation of $F_{\mathrm{EIA}}$ is based on a linear projection of nonroad diesel fuel consumption from 2002 to 2040, as described below. To establish a basis for estimaton of a growth rate, we derived estimates for the years 2002 and 2014 from AEO 2003, the derivation of which is described in Chapter 7.1 of the RIA. These two estimates, along with corresponding estimates from Draft NONROAD2004, are shown in Table 8A.2-1.

Table 8A.2-1
Nonroad Fuel Consumption: Draft NONROAD2004 and Estimates derived from EIA Sources
(Million gallons per year)

| Year | Draft NONROAD2004 | Derived from EIA Sources |
|---|---|---|
| 2002 | 10,625 | 8,428 |
| 2014 | 14,433 | 9,814 |

Using the following equation, we estimated a 1.4%/year average linear growth rate (without compounding) in fuel consumption $g_{\mathrm{EIA}}$ over this 12-year period:

$$g_{\mathrm{EIA}} = \frac{F_{\mathrm{EIA},2014} - F_{\mathrm{EIA},2002}}{2014 - 2002}\left(\frac{1}{F_{\mathrm{EIA},2002}}\right)$$

Using the resulting growth rate (0.014/year), we projected fuel consumption from 2002 to 2040, based on the expression

$$F_{\mathrm{EIA},y} = F_{\mathrm{EIA},2002}\left(1 + (y - 2002)g_{\mathrm{EIA}}\right)$$

The resulting EIA-derived fuel consumption estimates are shown in Table 8A.2-2, along with fuel consumption estimates from Draft NONROAD2004. The ratio of the two fuel consumption estimates in each year are also shown.

Table 8A.2-3 shows projected land-based nonroad diesel fuel consumption and associated emissions inventories ($NO_x$, $SO_2$, $PM_{10}$) at the national level for selected years between 2001 and 2040, as estimated by NONROAD and from EIA sources. Results are shown for both the base and control cases. These results are also presented graphically in Figures 8A.2-1 - 8A.2-4.

Table 8A.2-2
2001-2040 Nonroad Fuel Consumption (Million gallons per year)

| Calendar Year | Draft NONROAD2004 ($F_{NONROAD}$) | EIA FOKS/AEO Derived ($F_{EIA}$) | Ratio ($r$) |
|---|---|---|---|
| 2001 | 10,625 | 9,080 | 1.170 |
| 2002 | 10,919 | 8,428 | 1.296 |
| 2003 | 11,213 | 8,544 | 1.312 |
| 2004 | 11,507 | 8,659 | 1.329 |
| 2005 | 11,801 | 8,775 | 1.345 |
| 2006 | 12,092 | 8,890 | 1.360 |
| 2007 | 12,384 | 9,006 | 1.375 |
| 2008 | 12,676 | 9,121 | 1.390 |
| 2009 | 12,968 | 9,237 | 1.404 |
| 2010 | 13,259 | 9,352 | 1.418 |
| 2011 | 13,553 | 9,468 | 1.431 |
| 2012 | 13,846 | 9,583 | 1.445 |
| 2013 | 14,139 | 9,699 | 1.458 |
| 2014 | 14,433 | 9,814 | 1.471 |
| 2015 | 14,726 | 9,930 | 1.483 |
| 2016 | 15,016 | 10,045 | 1.495 |
| 2017 | 15,307 | 10,160 | 1.507 |
| 2018 | 15,597 | 10,276 | 1.518 |
| 2019 | 15,887 | 10,391 | 1.529 |
| 2020 | 16,178 | 10,507 | 1.540 |
| 2021 | 16,468 | 10,622 | 1.550 |
| 2022 | 16,759 | 10,738 | 1.561 |
| 2023 | 17,049 | 10,853 | 1.571 |
| 2024 | 17,339 | 10,969 | 1.581 |
| 2025 | 17,630 | 11,084 | 1.591 |
| 2026 | 17,918 | 11,200 | 1.600 |
| 2027 | 18,206 | 11,315 | 1.609 |
| 2028 | 18,495 | 11,431 | 1.618 |
| 2029 | 18,783 | 11,546 | 1.627 |
| 2030 | 19,071 | 11,662 | 1.635 |
| 2031 | 19,360 | 11,777 | 1.644 |
| 2032 | 19,648 | 11,892 | 1.652 |
| 2033 | 19,936 | 12,007 | 1.660 |
| 2034 | 20,225 | 12,123 | 1.668 |
| 2035 | 20,513 | 12,239 | 1.676 |
| 2036 | 20,801 | 12,354 | 1.684 |
| 2037 | 21,090 | 12,470 | 1.691 |
| 2038 | 21,378 | 12,585 | 1.699 |
| 2039 | 21,666 | 12,701 | 1.706 |
| 2040 | 21,955 | 12,816 | 1.713 |

Table 8A.2-3
*Case 1*: *Adjustment to Match EIA Projections*
Projected Nonroad Diesel Emissions Inventories

| Year (*y*) | National Emissions Inventory (thousand tons) | | | | | |
|---|---|---|---|---|---|---|
| | NOx | | $SO_2$ | | $PM_{10}$ | |
| | Base | Control | Base | Control | Base | Control |
| 2002 | 1,184 | 1,184 | 133 | 133 | 128 | 128 |
| 2005 | 1,096 | 1,096 | 139 | 139 | 111 | 111 |
| 2010 | 906 | 906 | 140 | 10.7 | 94.0 | 82.4 |
| 2015 | 781 | 650 | 145 | 0.673 | 87.9 | 55.4 |
| 2020 | 731 | 442 | 154 | 0.644 | 86.8 | 33.7 |
| 2025 | 722 | 334 | 162 | 0.644 | 88.1 | 21.2 |
| 2030 | 733 | 282 | 171 | 0.660 | 90.2 | 13.7 |
| 2035 | 754 | 259 | 179 | 0.684 | 92.8 | 9.5 |
| 2040 | 780 | 251 | 188 | 0.712 | 96.3 | 7.5 |

### 8A.2.2 Case 2: Large Equipment Population and Activity

To represent Case 2, we performed NONROAD runs with modified inputs for selected equipment types. Specifically, we used modified activity for large equipment (>750 hp) in five equipment types, as shown in Table 8A.2-4. This change represents the use of large equipment on a continuous shift basis. Additionally, we modified the fractions of generators assumed to be mobile, as opposed to stationary equipment, as shown in Table 8A.2-5. The modified fractions increased populations for generators of size 100 hp and greater, resulting in an increase in the total generator population of approximately 135,000 pieces. As in Case 1, we repeated the analysis for both the base and control cases.

Table 8A.3-6 shows projected land-based nonroad diesel fuel consumption and associated emissions inventories ($NO_x$, $SO_2$, $PM_{10}$) at the national level for selected years between 2001 and 2040, for both the base and control cases. These results are also presented graphically in Figures 8A.2-1 - 8A.2-4.

Table 8A.2-4
*Case 2*: *Large Equipment Population and Activity*
Annual Activity Estimates for Large Equipment (>750 hp)

| Equipment Type | Activity (hours/year) | |
|---|---|---|
| | FRM Base | Sensitivity Case |
| Excavators | 1,092 | 3,800 |
| Off-Highway Trucks | 1,641 | 3,800 |
| Rubber Tire Loaders | 761 | 3,800 |
| Crawler Tractors/Dozers | 936 | 3,800 |
| Off-Highway Tractors | 855 | 3,800 |
| Generators | 338 | 1,000 |

Table 8A.2-5
*Case 2*: *Large Equipment Population and Activity*
Modified Mobile-Equipment Population Fractions for Diesel Generators

| Hp Class | FRM Base | | Sensitivity Case | |
|---|---|---|---|---|
| | Mobile Fraction | Mobile Population | Mobile Fraction | Mobile Population |
| < 25 | 0.90 | 240,180 | 0.90 | 240,180 |
| 25-40 | 0.90 | 121,050 | 0.90 | 121,050 |
| 40-50 | 0.70 | 16,530 | 0.70 | 16,530 |
| 50-75 | 0.70 | 61,000 | 0.70 | 61,000 |
| 75-100 | 0.70 | 74,240 | 0.70 | 74,240 |
| 100-175 | 0.20 | 25,340 | 0.62 | 78,560 |
| 175-300 | 0.15 | 14,090 | 0.54 | 50,720 |
| 300-600 | 0.10 | 7,320 | 0.46 | 33,660 |
| 600-750 | 0.0 | 0 | 0.38 | 6,260 |
| > 750 | 0.0 | 0 | 0.30 | 12,290 |
| Total | | 559,750 | | 694,490 |

Table 8A.2-6

*Case 2*: *Large Equipment Population and Activity*:

Projected Nonroad Diesel Fuel Consumption and Emissions Inventories

| Year ($y$) | Fuel Consumption (million gal) | | National Emissions Inventory (thousand tons) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NONROAD FRM 50-state Base | NONROAD Sensitivity-Case | NOx | | $SO_2$ | | $PM_{10}$ | |
| | | | Base | Control | Base | Control | Base | Control |
| 2001 | 10,630 | 12,550 | 1,817 | 1,817 | 198 | 198 | 189 | 189 |
| 2005 | 11,800 | 13,960 | 1,759 | 1,759 | 220 | 220 | 165 | 165 |
| 2010 | 13,260 | 15,710 | 1,519 | 1,518 | 234 | 17.9 | 148 | 128 |
| 2015 | 14,730 | 17,470 | 1,409 | 1,132 | 256 | 1.15 | 145 | 89.3 |
| 2020 | 16,180 | 19,220 | 1,393 | 848 | 282 | 1.16 | 149 | 57.0 |
| 2025 | 17,630 | 20,970 | 1,434 | 692 | 307 | 1.21 | 156 | 38.2 |
| 2030 | 19,070 | 22,710 | 1,502 | 916 | 333 | 1.28 | 164 | 26.4 |
| 2035 | 20,510 | 24,440 | 1,585 | 595 | 358 | 1.37 | 173 | 19.3 |
| 2040 | 21,950 | 26,180 | 1,678 | 594 | 384 | 1.45 | 183 | 16.0 |

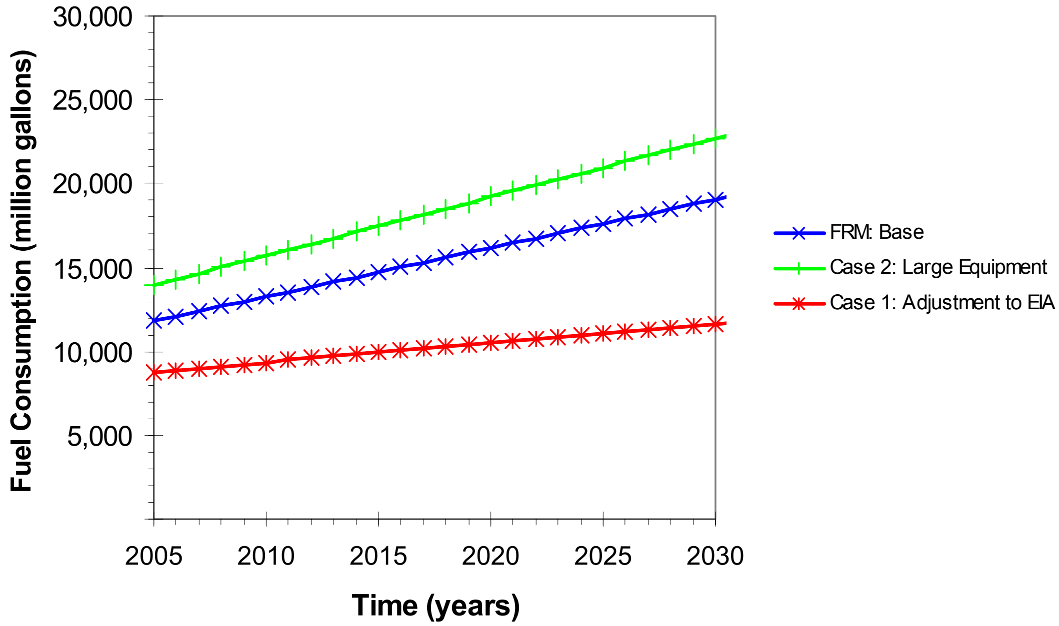


Figure 8A.2-1. Projected land-based nonroad diesel fuel consumption at the national level for the FRM base and two sensitivity cases. Case 1 represents Draft NONROAD2004 estimates adjusted to match EIA-based projections; Case 2 represents modified population and activity estimates for large equipment (>750 hp).

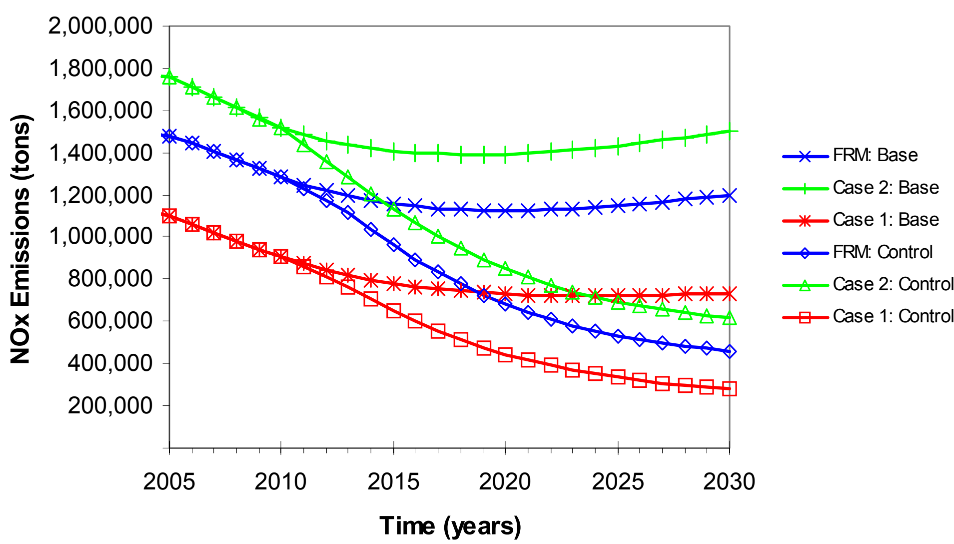


Figure 8A.2-2. Projected land-based nonroad NOx inventories at the national level for the FRM base and two sensitivity cases. Case 1 represents Draft NONROAD2004 estimates adjusted to match EIA-based projections; Case 2 represents modified population and activity estimates for large equipment (>750 hp).

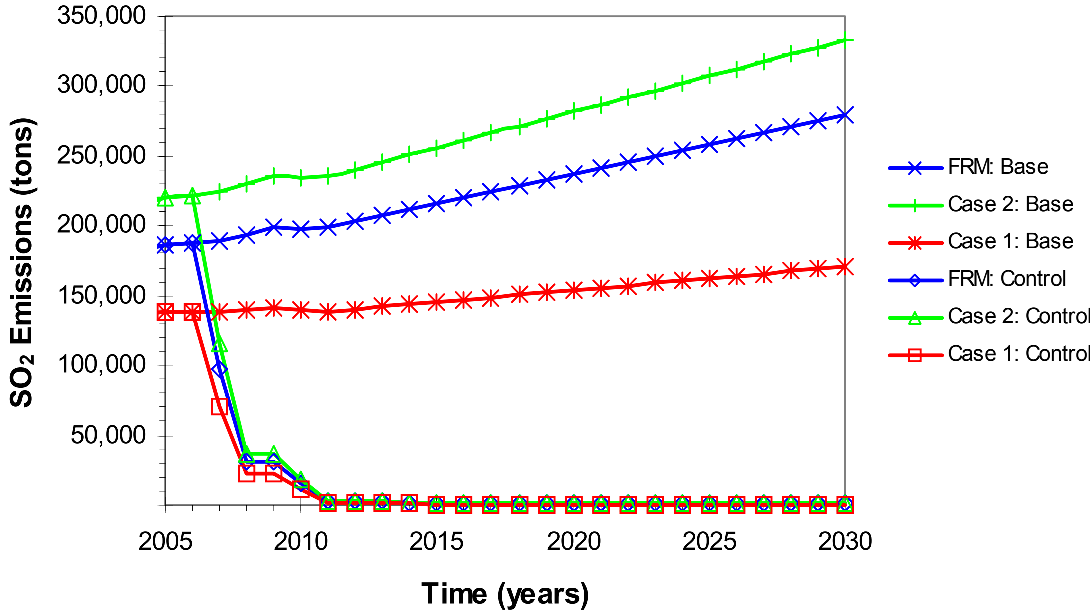


Figure 8A.2-3. Projected land-based nonroad $SO_2$ inventories at the national level for the FRM base and two sensitivity cases. Case 1 represents Draft NONROAD2004 estimates adjusted to match EIA-based projections; Case 2 represents modified population and activity estimates for large equipment (>750 hp).

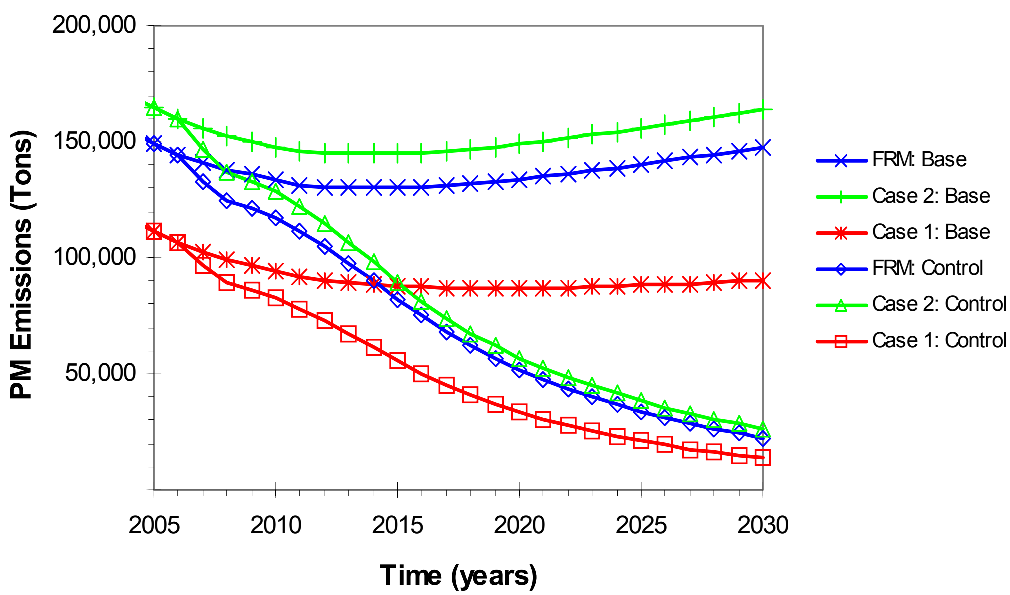


Figure 8A.2-4. Projected land-based nonroad $PM_{10}$ inventories at the national level for the FRM base and two sensitivity cases. Case 1 represents Draft NONROAD2004 estimates adjusted to match EIA-based projections; Case 2 represents modified population and activity estimates for large equipment (>750 hp).

## 8A.3 What Are the Costs and Costs per Ton?

Here we look at the cost per ton of two sensitivity cases—a Case 1 sensitivity using future fuel consumption projections developed by the Energy Information Administration (EIA); and, a Case 2 sensitivity that incorporates more generator sets in both the costs and emissions reductions estimates than are incorporated under NRT4 full engine and fuel program (i.e., the NRT4 final rule estimates).

### 8A.3.1 Costs and Costs per Ton for the Case 1 Sensitivity

Under the Case 1 sensitivity we use future fuel projections developed by EIA rather than using the projections generated in our NONROAD model as discussed in Section 8A.1. Doing this results in lower fuel-related costs (including all operating costs expressed throughout this Regulatory Impact Analysis on a cent-per-gallon basis) since the EIA projections are lower than our model's projections. Doing this also results in lower emissions reductions as discussed in Section 8A.2. The engine and equipment costs under the Case 1 sensitivity would be identical to those under the full engine and fuel program since all engine standards would still be implemented. Tables 8A.3-1 though 8A.3-4 show all fuel-related costs associated with the Case 1 sensitivity. All these tables are analogous to Tables 8.4-1 through 8.4-4 presented above for the NRT4 final program. The cent per gallon fuel costs are presented in Table 7.5-1.

Table 8A.3-1
Aggregate Fuel Costs of the Case 1 Sensitivity ($2002)

| Year | Affected NR Fuel | | Affected L&M Fuel | | Fuel Cost * | | NR Fuel Costs | | | L&M Fuel Costs | | | NRLM Annual Fuel Costs ($10^6$ dollars) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | 500 ppm ($/gal) | 15 ppm ($/gal) | 500 ppm ($10^6$ dollars) | 15 ppm ($10^6$ dollars) | Total ($10^6$ dollars) | 500 ppm ($10^6$ dollars) | 15 ppm ($10^6$ dollars) | Total ($10^6$ dollars) | |
| 2007 | 3,671 | - | 1,981 | - | $ 0.021 | $ - | $ 77 | - | $ 77 | $ 42 | $ - | $ 42 | $ 119 |
| 2008 | 6,373 | - | 3,438 | - | $ 0.021 | $ - | $ 134 | - | $ 134 | $ 72 | $ - | $ 72 | $ 206 |
| 2009 | 6,454 | - | 3,483 | - | $ 0.021 | $ - | $ 136 | - | $ 136 | $ 73 | $ - | $ 73 | $ 209 |
| 2010 | 3,086 | 3,873 | 3,069 | - | $ 0.029 | $ 0.058 | $ 88 | 225 | $ 313 | $ 88 | $ - | $ 88 | $ 401 |
| 2011 | 631 | 6,721 | 2,785 | - | $ 0.034 | $ 0.058 | $ 21 | 390 | $ 411 | $ 95 | $ - | $ 95 | $ 506 |
| 2012 | 531 | 6,574 | 1,243 | 2,116 | $ 0.035 | $ 0.062 | $ 18 | 404 | $ 423 | $ 43 | $ 130 | $ 173 | $ 596 |
| 2013 | 460 | 6,488 | 120 | 3,657 | $ 0.036 | $ 0.064 | $ 16 | 415 | $ 431 | $ 4 | $ 234 | $ 238 | $ 670 |
| 2014 | 194 | 7,153 | 50 | 3,527 | $ 0.036 | $ 0.067 | $ 7 | 479 | $ 485 | $ 2 | $ 236 | $ 238 | $ 723 |
| 2015 | - | 7,662 | - | 3,441 | | $ 0.069 | $ - | 529 | $ 529 | $ - | $ 237 | $ 237 | $ 766 |
| 2016 | - | 7,751 | - | 3,476 | | $ 0.069 | $ - | 535 | $ 535 | $ - | $ 240 | $ 240 | $ 775 |
| 2017 | - | 7,840 | - | 3,511 | | $ 0.069 | $ - | 541 | $ 541 | $ - | $ 242 | $ 242 | $ 783 |
| 2018 | - | 7,929 | - | 3,551 | | $ 0.069 | $ - | 547 | $ 547 | $ - | $ 245 | $ 245 | $ 792 |
| 2019 | - | 8,018 | - | 3,598 | | $ 0.069 | $ - | 553 | $ 553 | $ - | $ 248 | $ 248 | $ 802 |
| 2020 | - | 8,107 | - | 3,632 | | $ 0.069 | $ - | 559 | $ 559 | $ - | $ 251 | $ 251 | $ 810 |
| 2021 | - | 8,196 | - | 3,663 | | $ 0.069 | $ - | 566 | $ 566 | $ - | $ 253 | $ 253 | $ 818 |
| 2022 | - | 8,285 | - | 3,709 | | $ 0.069 | $ - | 572 | $ 572 | $ - | $ 256 | $ 256 | $ 828 |
| 2023 | - | 8,374 | - | 3,747 | | $ 0.069 | $ - | 578 | $ 578 | $ - | $ 259 | $ 259 | $ 836 |
| 2024 | - | 8,464 | - | 3,788 | | $ 0.069 | $ - | 584 | $ 584 | $ - | $ 261 | $ 261 | $ 845 |
| 2025 | - | 8,553 | - | 3,828 | | $ 0.069 | $ - | 590 | $ 590 | $ - | $ 264 | $ 264 | $ 854 |
| 2026 | - | 8,642 | - | 3,868 | | $ 0.069 | $ - | 596 | $ 596 | $ - | $ 267 | $ 267 | $ 863 |
| 2027 | - | 8,731 | - | 3,909 | | $ 0.069 | $ - | 602 | $ 602 | $ - | $ 270 | $ 270 | $ 872 |
| 2028 | - | 8,820 | - | 3,949 | | $ 0.069 | $ - | 609 | $ 609 | $ - | $ 272 | $ 272 | $ 881 |
| 2029 | - | 8,909 | - | 3,989 | | $ 0.069 | $ - | 615 | $ 615 | $ - | $ 275 | $ 275 | $ 890 |
| 2030 | - | 8,998 | - | 4,029 | | $ 0.069 | $ - | 621 | $ 621 | $ - | $ 278 | $ 278 | $ 899 |
| 2031 | - | 9,087 | - | 4,070 | | $ 0.069 | $ - | 627 | $ 627 | $ - | $ 281 | $ 281 | $ 908 |
| 2032 | - | 9,176 | - | 4,110 | | $ 0.069 | $ - | 633 | $ 633 | $ - | $ 284 | $ 284 | $ 917 |
| 2033 | - | 9,265 | - | 4,150 | | $ 0.069 | $ - | 639 | $ 639 | $ - | $ 286 | $ 286 | $ 926 |
| 2034 | - | 9,354 | - | 4,190 | | $ 0.069 | $ - | 645 | $ 645 | $ - | $ 289 | $ 289 | $ 935 |
| 2035 | - | 9,444 | - | 4,231 | | $ 0.069 | $ - | 652 | $ 652 | $ - | $ 292 | $ 292 | $ 944 |
| 2036 | - | 9,533 | - | 4,271 | | $ 0.069 | $ - | 658 | $ 658 | $ - | $ 295 | $ 295 | $ 952 |
| 30 Yr NPV at 3% | 18,602 | 124,895 | 13,818 | 52,202 | | | $ 430 | $ 8,447 | $ 8,877 | $ 354 | $ 3,570 | $ 3,924 | $ 12,801 |
| 30 Yr NPV at 7% | 15,567 | 64,783 | 11,317 | 26,078 | | | $ 357 | $ 4,342 | $ 4,698 | $ 287 | $ 1,776 | $ 2,063 | $ 6,762 |

*Fuel costs are relative to uncontrolled fuel and assume that, during the transitional years of 2010, 2012, & 2014, the first 5 months are at the previous year's cost and the remaining 7 months are at the next year's cost.
See Appendix 8B for information on how these fuel volumes were developed.

Table 8A.3-2
Oil Change Maintenance Savings Associated with the Case 1 Sensitivity ($2002)

| Year | Affected NR Fuel | | Affected L&M Fuel | | NR Savings | | L&M Savings | | NRLM |
|---|---|---|---|---|---|---|---|---|---|
| | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | 500 ppm ($10^6$ gallons) | 15 ppm ($10^6$ gallons) | savings=$0.029/gal ($10^6$ dollars) | savings=$0.032/gal ($10^6$ dollars) | savings=$0.010/gal ($10^6$ dollars) | savings=$0.011/gal ($10^6$ dollars) | Total Savings ($10^6$ dollars) |
| 2007 | 3,671 | - | 1,981 | - | $ 107 | $ - | $ 21 | $ - | $ 128 |
| 2008 | 6,373 | - | 3,438 | - | $ 186 | $ - | $ 36 | $ - | $ 222 |
| 2009 | 6,454 | - | 3,483 | - | $ 189 | $ - | $ 36 | $ - | $ 225 |
| 2010 | 3,086 | 3,873 | 3,069 | - | $ 90 | $ 124 | $ 32 | $ - | $ 246 |
| 2011 | 631 | 6,721 | 2,785 | - | $ 18 | $ 215 | $ 29 | $ - | $ 263 |
| 2012 | 531 | 6,574 | 1,243 | 2,116 | $ 16 | $ 211 | $ 13 | $ 24 | $ 263 |
| 2013 | 460 | 6,488 | 120 | 3,657 | $ 13 | $ 208 | $ 1 | $ 42 | $ 264 |
| 2014 | 194 | 7,153 | 50 | 3,527 | $ 6 | $ 229 | $ 1 | $ 40 | $ 276 |
| 2015 | - | 7,662 | - | 3,441 | $ - | $ 245 | $ - | $ 39 | $ 285 |
| 2016 | - | 7,751 | - | 3,476 | $ - | $ 248 | $ - | $ 40 | $ 288 |
| 2017 | - | 7,840 | - | 3,511 | $ - | $ 251 | $ - | $ 40 | $ 291 |
| 2018 | - | 7,929 | - | 3,551 | $ - | $ 254 | $ - | $ 41 | $ 295 |
| 2019 | - | 8,018 | - | 3,598 | $ - | $ 257 | $ - | $ 41 | $ 298 |
| 2020 | - | 8,107 | - | 3,632 | $ - | $ 260 | $ - | $ 42 | $ 301 |
| 2021 | - | 8,196 | - | 3,663 | $ - | $ 263 | $ - | $ 42 | $ 305 |
| 2022 | - | 8,285 | - | 3,709 | $ - | $ 265 | $ - | $ 43 | $ 308 |
| 2023 | - | 8,374 | - | 3,747 | $ - | $ 268 | $ - | $ 43 | $ 311 |
| 2024 | - | 8,464 | - | 3,788 | $ - | $ 271 | $ - | $ 43 | $ 315 |
| 2025 | - | 8,553 | - | 3,828 | $ - | $ 274 | $ - | $ 44 | $ 318 |
| 2026 | - | 8,642 | - | 3,868 | $ - | $ 277 | $ - | $ 44 | $ 321 |
| 2027 | - | 8,731 | - | 3,909 | $ - | $ 280 | $ - | $ 45 | $ 324 |
| 2028 | - | 8,820 | - | 3,949 | $ - | $ 282 | $ - | $ 45 | $ 328 |
| 2029 | - | 8,909 | - | 3,989 | $ - | $ 285 | $ - | $ 46 | $ 331 |
| 2030 | - | 8,998 | - | 4,029 | $ - | $ 288 | $ - | $ 46 | $ 334 |
| 2031 | - | 9,087 | - | 4,070 | $ - | $ 291 | $ - | $ 47 | $ 338 |
| 2032 | - | 9,176 | - | 4,110 | $ - | $ 294 | $ - | $ 47 | $ 341 |
| 2033 | - | 9,265 | - | 4,150 | $ - | $ 297 | $ - | $ 48 | $ 344 |
| 2034 | - | 9,354 | - | 4,190 | $ - | $ 300 | $ - | $ 48 | $ 348 |
| 2035 | - | 9,444 | - | 4,231 | $ - | $ 302 | $ - | $ 49 | $ 351 |
| 2036 | - | 9,533 | - | 4,271 | $ - | $ 305 | $ - | $ 49 | $ 354 |
| 30 Yr NPV at 3% | 18,602 | 124,895 | 13,818 | 52,202 | $ 544 | $ 4,000 | $ 145 | $ 599 | $ 5,287 |
| 30 Yr NPV at 7% | 15,567 | 64,783 | 11,317 | 26,078 | $ 455 | $ 2,075 | $ 118 | $ 299 | $ 2,948 |

Table 8A.3-3
CDPF Maintenance and CDPF Regeneration Costs Associated with the Case 1 Sensitivity
($2002)

| Year | Fuel Consumed in New CDPF Equipped Engines ($10^6$ gallons) | Weighted Maintenance Cost ($/gal) | Weighted Regeneration Cost ($/gal) | CDPF Maintenance Cost ($10^6$ dollars) | CDPF Regeneration Cost ($10^6$ dollars) | Total Costs ($10^6$ dollars) |
|---|---|---|---|---|---|---|
| 2007 | - | $ - | $ - | $ - | $ - | $ - |
| 2008 | - | $ - | $ - | $ - | $ - | $ - |
| 2009 | - | $ - | $ - | $ - | $ - | $ - |
| 2010 | - | $ - | $ - | $ - | $ - | $ - |
| 2011 | 461 | $ 0.002 | $ 0.010 | $ 1 | $ 5 | $ 5 |
| 2012 | 1,204 | $ 0.003 | $ 0.010 | $ 4 | $ 12 | $ 16 |
| 2013 | 2,076 | $ 0.005 | $ 0.010 | $ 10 | $ 21 | $ 32 |
| 2014 | 2,953 | $ 0.006 | $ 0.007 | $ 17 | $ 22 | $ 39 |
| 2015 | 3,885 | $ 0.006 | $ 0.008 | $ 23 | $ 30 | $ 53 |
| 2016 | 4,782 | $ 0.006 | $ 0.008 | $ 29 | $ 38 | $ 66 |
| 2017 | 5,612 | $ 0.006 | $ 0.008 | $ 34 | $ 45 | $ 79 |
| 2018 | 6,369 | $ 0.006 | $ 0.008 | $ 39 | $ 51 | $ 90 |
| 2019 | 7,056 | $ 0.006 | $ 0.008 | $ 43 | $ 57 | $ 100 |
| 2020 | 7,685 | $ 0.006 | $ 0.008 | $ 47 | $ 62 | $ 110 |
| 2021 | 8,239 | $ 0.006 | $ 0.008 | $ 50 | $ 67 | $ 118 |
| 2022 | 8,726 | $ 0.006 | $ 0.008 | $ 53 | $ 71 | $ 124 |
| 2023 | 9,168 | $ 0.006 | $ 0.008 | $ 56 | $ 75 | $ 131 |
| 2024 | 9,579 | $ 0.006 | $ 0.008 | $ 59 | $ 78 | $ 137 |
| 2025 | 9,962 | $ 0.006 | $ 0.008 | $ 61 | $ 81 | $ 142 |
| 2026 | 10,314 | $ 0.006 | $ 0.008 | $ 63 | $ 84 | $ 147 |
| 2027 | 10,622 | $ 0.006 | $ 0.008 | $ 65 | $ 87 | $ 152 |
| 2028 | 10,896 | $ 0.006 | $ 0.008 | $ 67 | $ 89 | $ 156 |
| 2029 | 11,151 | $ 0.006 | $ 0.008 | $ 68 | $ 91 | $ 159 |
| 2030 | 11,390 | $ 0.006 | $ 0.008 | $ 70 | $ 93 | $ 163 |
| 2031 | 11,612 | $ 0.006 | $ 0.008 | $ 71 | $ 95 | $ 166 |
| 2032 | 11,823 | $ 0.006 | $ 0.008 | $ 72 | $ 96 | $ 169 |
| 2033 | 12,027 | $ 0.006 | $ 0.008 | $ 74 | $ 98 | $ 172 |
| 2034 | 12,224 | $ 0.006 | $ 0.008 | $ 75 | $ 100 | $ 174 |
| 2035 | 12,407 | $ 0.006 | $ 0.008 | $ 76 | $ 101 | $ 177 |
| 2036 | 12,579 | $ 0.006 | $ 0.008 | $ 77 | $ 102 | $ 180 |
| 30 Yr NPV at 3% | 111,737 | | | $ 675 | $ 911 | $ 1,587 |
| 30 Yr NPV at 7% | 50,796 | | | $ 305 | $ 415 | $ 720 |

* Note that fuel used in CDPF engines includes some highway spillover fuel.
**Weighted Regeneration Cost ($/gal) changes year-to-year due to different fuel economy impacts with a NOx adsorber (1 percent) and without a NOx adsorber (2 percent) matched with the phase-in schedules of the emission standards.

Table 8A.3-4
CCV Maintenance Costs Associated with the Case 1 Sensitivity
($2002)

| Year | Fuel Consumed in Engines Adding CCV System ($10^6$ gallons) | Weighted Maintenance Cost ($/gal) | Total Costs ($10^6$ dollars) |
|---|---|---|---|
| 2007 | - | $ - | $ - |
| 2008 | 183 | $ 0.000 | $ 0 |
| 2009 | 186 | $ 0.000 | $ 0 |
| 2010 | 173 | $ 0.000 | $ 0 |
| 2011 | 778 | $ 0.001 | $ 1 |
| 2012 | 1,606 | $ 0.001 | $ 2 |
| 2013 | 2,561 | $ 0.002 | $ 4 |
| 2014 | 3,496 | $ 0.002 | $ 5 |
| 2015 | 4,478 | $ 0.002 | $ 7 |
| 2016 | 5,447 | $ 0.002 | $ 8 |
| 2017 | 6,339 | $ 0.002 | $ 10 |
| 2018 | 7,133 | $ 0.002 | $ 11 |
| 2019 | 7,855 | $ 0.002 | $ 12 |
| 2020 | 8,516 | $ 0.002 | $ 13 |
| 2021 | 9,099 | $ 0.002 | $ 14 |
| 2022 | 9,612 | $ 0.002 | $ 14 |
| 2023 | 10,076 | $ 0.002 | $ 15 |
| 2024 | 10,505 | $ 0.002 | $ 16 |
| 2025 | 10,905 | $ 0.002 | $ 16 |
| 2026 | 11,271 | $ 0.002 | $ 17 |
| 2027 | 11,593 | $ 0.002 | $ 18 |
| 2028 | 11,879 | $ 0.002 | $ 18 |
| 2029 | 12,146 | $ 0.002 | $ 18 |
| 2030 | 12,398 | $ 0.002 | $ 19 |
| 2031 | 12,631 | $ 0.002 | $ 19 |
| 2032 | 12,853 | $ 0.002 | $ 19 |
| 2033 | 13,069 | $ 0.002 | $ 20 |
| 2034 | 13,277 | $ 0.002 | $ 20 |
| 2035 | 13,471 | $ 0.002 | $ 20 |
| 2036 | 13,654 | $ 0.002 | $ 21 |
| 30 Yr NPV at 3% | 124,105 | | $ 187 |
| 30 Yr NPV at 7% | 56,982 | | $ 86 |

* Weighted Maintenance Cost ($/gal) changes year-to-year due to the implementation schedule for engines adding the CCV system.

Using Tables 8A.3-1 through 8A.3-4 and Table 8.2-2 (engine fixed costs by pollutant), Table 8.2-4 (engine variable costs by pollutant), Table 8.3-2 (equipment fixed costs by pollutant), and Table 8.3-4 (equipment variable costs) we can generate the annual costs and costs by pollutant for the Case 1 sensitivity. Table 8A.3-5 shows these results (this table is analogous to Tables 8.5-1 and 8.5-2 for the NRT4 final program). Note that the pollutant allocations for the Case 1 sensitivity are identical to those used for the NRT4 final program (see Table 8.1-2). Also shown in Table 8A.3-5 are the emissions reductions associated with the Case 1 sensitivity (these values are analogous to Table 8.6-1 for the NRT4 final program).

Table 8A.3-5
Summary of Aggregate Costs, Costs by Pollutant, and Emissions Reductions Associated with the Case 1 Sensitivity ($2002)

| Year | Engine Costs ($million) | Equipment Costs ($million) | Fuel Costs ($million) | Other Operating Costs ($million) | Net Operating Costs ($million) | Total Annual Costs ($million) | PM Costs ($million) | NOx+NMHC Costs ($million) | SOx Costs ($million) | PM Reduction (tons) | NOx+NMHC Reduction (tons) | SOx Reduction (tons) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | $ - | $ - | $ 119 | $ (128) | $ (9) | $ (9) | $ (3) | $ - | $ (6) | 7,100 | - | 87,600 |
| 2008 | $ 81 | $ 5 | $ 206 | $ (222) | $ (16) | $ 69 | $ 80 | $ 0 | $ (11) | 12,700 | 100 | 153,200 |
| 2009 | $ 82 | $ 5 | $ 209 | $ (225) | $ (16) | $ 71 | $ 81 | $ 0 | $ (11) | 13,200 | 200 | 154,400 |
| 2010 | $ 80 | $ 5 | $ 401 | $ (246) | $ 154 | $ 239 | $ 145 | $ 25 | $ 69 | 15,800 | 400 | 186,500 |
| 2011 | $ 403 | $ 62 | $ 506 | $ (256) | $ 250 | $ 715 | $ 441 | $ 170 | $ 104 | 19,000 | 13,200 | 201,600 |
| 2012 | $ 718 | $ 106 | $ 596 | $ (245) | $ 351 | $ 1,174 | $ 735 | $ 282 | $ 157 | 23,200 | 34,100 | 209,500 |
| 2013 | $ 882 | $ 121 | $ 670 | $ (229) | $ 440 | $ 1,444 | $ 912 | $ 330 | $ 201 | 27,900 | 57,500 | 215,500 |
| 2014 | $ 973 | $ 146 | $ 723 | $ (232) | $ 491 | $ 1,610 | $ 893 | $ 501 | $ 215 | 32,800 | 97,100 | 218,500 |
| 2015 | $ 950 | $ 149 | $ 766 | $ (225) | $ 541 | $ 1,640 | $ 911 | $ 503 | $ 226 | 37,900 | 136,200 | 221,300 |
| 2016 | $ 920 | $ 150 | $ 775 | $ (214) | $ 561 | $ 1,631 | $ 914 | $ 487 | $ 229 | 42,500 | 173,800 | 223,400 |
| 2017 | $ 910 | $ 150 | $ 783 | $ (203) | $ 580 | $ 1,640 | $ 924 | $ 485 | $ 231 | 47,000 | 209,400 | 225,500 |
| 2018 | $ 901 | $ 146 | $ 792 | $ (194) | $ 598 | $ 1,645 | $ 922 | $ 489 | $ 234 | 51,100 | 241,700 | 227,700 |
| 2019 | $ 890 | $ 147 | $ 802 | $ (186) | $ 615 | $ 1,652 | $ 944 | $ 471 | $ 237 | 54,900 | 271,800 | 230,100 |
| 2020 | $ 900 | $ 147 | $ 810 | $ (179) | $ 631 | $ 1,678 | $ 962 | $ 477 | $ 239 | 58,500 | 299,400 | 232,200 |
| 2021 | $ 913 | $ 99 | $ 818 | $ (173) | $ 645 | $ 1,657 | $ 957 | $ 458 | $ 241 | 61,700 | 324,000 | 234,200 |
| 2022 | $ 927 | $ 66 | $ 828 | $ (169) | $ 659 | $ 1,651 | $ 959 | $ 448 | $ 244 | 64,700 | 346,100 | 236,600 |
| 2023 | $ 940 | $ 56 | $ 836 | $ (165) | $ 671 | $ 1,667 | $ 972 | $ 448 | $ 247 | 67,400 | 366,500 | 238,800 |
| 2024 | $ 954 | $ 36 | $ 845 | $ (162) | $ 683 | $ 1,672 | $ 989 | $ 433 | $ 250 | 70,000 | 385,000 | 241,100 |
| 2025 | $ 967 | $ 32 | $ 854 | $ (159) | $ 695 | $ 1,694 | $ 1,002 | $ 439 | $ 252 | 72,400 | 402,200 | 243,300 |
| 2026 | $ 980 | $ 32 | $ 863 | $ (157) | $ 706 | $ 1,719 | $ 1,019 | $ 445 | $ 255 | 74,700 | 417,900 | 245,600 |
| 2027 | $ 994 | $ 33 | $ 872 | $ (155) | $ 717 | $ 1,743 | $ 1,035 | $ 451 | $ 258 | 76,800 | 432,200 | 247,900 |
| 2028 | $ 1,007 | $ 33 | $ 881 | $ (154) | $ 727 | $ 1,767 | $ 1,050 | $ 457 | $ 260 | 78,600 | 445,200 | 250,100 |
| 2029 | $ 1,021 | $ 33 | $ 890 | $ (153) | $ 737 | $ 1,791 | $ 1,065 | $ 463 | $ 263 | 80,400 | 457,300 | 252,400 |
| 2030 | $ 1,034 | $ 34 | $ 899 | $ (153) | $ 746 | $ 1,814 | $ 1,080 | $ 469 | $ 265 | 82,100 | 468,000 | 254,700 |
| 2031 | $ 1,048 | $ 34 | $ 908 | $ (153) | $ 755 | $ 1,837 | $ 1,094 | $ 474 | $ 268 | 83,600 | 477,900 | 257,100 |
| 2032 | $ 1,061 | $ 35 | $ 917 | $ (153) | $ 764 | $ 1,860 | $ 1,109 | $ 480 | $ 271 | 85,000 | 487,400 | 259,400 |
| 2033 | $ 1,074 | $ 35 | $ 926 | $ (153) | $ 773 | $ 1,882 | $ 1,123 | $ 486 | $ 273 | 86,400 | 496,300 | 261,700 |
| 2034 | $ 1,088 | $ 35 | $ 935 | $ (153) | $ 781 | $ 1,905 | $ 1,137 | $ 492 | $ 276 | 87,800 | 504,900 | 264,100 |
| 2035 | $ 1,101 | $ 36 | $ 944 | $ (154) | $ 790 | $ 1,927 | $ 1,151 | $ 497 | $ 279 | 89,000 | 512,900 | 266,400 |
| 2036 | $ 1,115 | $ 36 | $ 952 | $ (154) | $ 798 | $ 1,949 | $ 1,165 | $ 503 | $ 281 | 90,200 | 520,600 | 268,800 |
| 30 Yr NPV at 3% | $ 14,054 | $ 1,281 | $ 12,801 | $ (3,514) | $ 9,286 | $ 24,622 | $ 14,505 | $ 6,590 | $ 3,527 | 919,400 | 4,421,600 | 4,032,300 |
| 30 Yr NPV at 7% | $ 7,215 | $ 754 | $ 6,762 | $ (2,143) | $ 4,619 | $ 12,588 | $ 7,429 | $ 3,372 | $ 1,787 | 450,100 | 1,981,700 | 2,240,800 |

The calculations of cost per ton of each emission reduced under the Case 1 sensitivity divides the net present value of the annual costs assigned to each pollutant (Table 8A.3-5) by the net present value of the total annual reductions of each pollutant (Table 8A.3-5). The 30-year net present value of the costs associated with each pollutant, calculated with a three percent discount rate, are shown in Table 8A.3-5 as $6.6 billion for NOx+NMHC, $14.5 billion for PM, and $3.5 billion for SOx with the total cost of the program estimated at $24.6 billion. The 30-year net present value, with a three percent discount rate, of emission reductions are estimated at 4.4 million tons of NOx+NMHC, 919 thousand tons of PM and 4.0 million tons of SOx (see Table 8A.3-5). How these emissions reductions were developed is described in Section 8A.2 (see Table 8A.2-3).[I] The results of the cost per ton calculations are shown in Table 8A.3-6.

Table 8A.3-6
Aggregate Cost per Ton for the Case 1 Sensitivity
30-year Net Present Values at a 3% and 7% Discount Rate ($2002)

| Item | 3% discount rate | 7% discount rate | Source |
|---|---|---|---|
| Cost per Ton NOx+NMHC | $1,490 | $1,700 | Calculated |
| Cost per Ton PM | $15,800 | $16,500 | Calculated |
| Cost per Ton SOx | $870 | $800 | Calculated |

We have also calculated the cost per ton of emissions reduced in the year 2030 using the annual costs and emission reductions in that year alone. This number, shown in Table 8A.3-7, approaches the long-term cost per ton of emissions reduced.

[I] Note that the emissions reductions shown in Table 8A.3-5 are not identical to the reductions one would get using the inventories presented in Table 8A.2-3. The emissions inventories in Table 8A.2-3 are for land based nonroad engines only and do not include emissions associated with locomotive and marine engines. To make the comparison between the Case 1 $/ton and the NRT4 full program $/ton, the Case 1 locomotive and marine emissions reductions are included with the Case 1 nonroad land based emissions reductions. Because the emissions reductions associated with locomotive and marine engines are directly proportional to gallons of fuel consumed (because no new emission control hardware is being added to those engines), we have calculated the locomotive and marine emissions reductions by taking the ratio of the Case 1 locomotive and marine gallons consumed to the NRT4 full program locomotive and marine gallons consumed and multiplied that ratio by the NRT4 locomotive and marine emissions reductions to arrive at the Case 1 locomotive and marine emissions reductions. These Case 1 locomotive and marine emissions reductions were then added to the Case 1 nonroad land based emissions reductions to arrive at the Case 1 emissions reductions shown in Table 8A.3-5.

Table 8A.3-7
Long-Term Cost per Ton of the Case 1 Sensitivity
Annual Values without Discounting ($2002)

| Pollutant | Long-Term Cost per Ton in 2030 |
|---|---|
| NOx+NMHC | $1,000 |
| PM | $13,200 |
| SOx | $1,050 |

### 8A.3.2 Costs and Costs per Ton of the Case 2 Sensitivity

Under the Case 2 sensitivity, more generator sets are assumed to be mobile than are assumed under NRT4 full engine and fuel program, as described in Section 8A.1. This results in higher engine and equipment variable costs since more generator sets (gensets) add NOx adsorbers and CDPFs and more equipment fixed costs since more machines must undergo redesign and product support literature changes. Engine fixed costs would not change since we believe that the R&D work estimated for the NRT4 full program would cover these additional gensets. Fuel-related costs would also increase because more machines would incur CDPF and CCV maintenance costs and CDPF regeneration costs. Increased costs for the incrementally higher cost fuel and savings associated with that fuel should not change since our earlier calculations for the NRT4 full engine and fuel program would have included these costs (i.e., those costs and savings are included in the NRT4 final rule).

We have calculated the increased engine variable costs using the equations shown in Table 6.4-2 and have applied those costs to the same nonroad engine fleet with the exception that more gensets are included. Likewise, we followed the same process for developing equipment costs as described in Chapter 6 to generate the higher equipment fixed and variable costs.

Because more machines are adding the new engine hardware (CDPFs and NOx adsorbers), the emissions reductions associated with the Case 2 sensitivity would be higher than under the NRT4 final program. These higher emissions reductions were generated using our NONROAD model as discussed in section 8A.2.2. These emissions reductions are directly proportional to the increased amount of fuel that would be consumed in these additional engines and, likewise, to the increased fuel-related costs under this sensitivity. Using that direct relationship, we can estimate the incremental fuel-related costs by calculating the ratio of fuel-related costs under the full engine and fuel program to the emissions reductions under the full engine and fuel program and then applying that ratio to the emissions reductions under the Case 2 sensitivity. Table 8A.3-8 presents the annual costs, the costs by pollutant, and the emissions reductions of the Case 2 sensitivity. Note that costs have been allocated as done under the NRT4 full engine and fuel program (see Table 8.1-2). Note also that the emissions reductions shown in Table 8A.3-8 include the higher reductions from gensets and the nonroad, locomotive, and marine reductions that would occur under the full engine and fuel program.

Table 8A.3-8
Summary of Aggregate Costs, Costs by Pollutant, and Emissions Reductions Associated with the Case 2 Sensitivity ($2002)

| Year | Engine Costs ($million) | Equipment Costs ($million) | Fuel Costs ($million) | Other Operating Costs ($million) | Net Operating Costs ($million) | Total Annual Costs ($million) | PM Costs ($million) | NOx+NMHC Costs ($million) | SOx Costs ($million) | PM Reduction (tons) | NOx+NMHC Reduction (tons) | SOx Reduction (tons) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | $ - | $ - | $ 161 | $ (181) | $ (21) | $ (21) | $ (7) | $ - | $ (14) | 12,100 | - | 149,900 |
| 2008 | $ 81 | $ 5 | $ 281 | $ (318) | $ (37) | $ 49 | $ 73 | $ 0 | $ (25) | 21,900 | 200 | 265,500 |
| 2009 | $ 82 | $ 5 | $ 286 | $ (324) | $ (38) | $ 49 | $ 74 | $ 0 | $ (26) | 22,900 | 300 | 270,900 |
| 2010 | $ 80 | $ 5 | $ 602 | $ (375) | $ 228 | $ 312 | $ 179 | $ 34 | $ 99 | 25,000 | 600 | 289,300 |
| 2011 | $ 423 | $ 67 | $ 811 | $ (415) | $ 396 | $ 885 | $ 486 | $ 267 | $ 133 | 29,700 | 45,600 | 304,900 |
| 2012 | $ 745 | $ 111 | $ 902 | $ (383) | $ 520 | $ 1,376 | $ 803 | $ 377 | $ 195 | 37,000 | 100,500 | 315,000 |
| 2013 | $ 906 | $ 126 | $ 984 | $ (352) | $ 631 | $ 1,663 | $ 996 | $ 421 | $ 246 | 45,000 | 152,300 | 323,800 |
| 2014 | $ 1,000 | $ 151 | $ 1,041 | $ (349) | $ 691 | $ 1,842 | $ 987 | $ 591 | $ 264 | 53,100 | 215,900 | 330,700 |
| 2015 | $ 989 | $ 157 | $ 1,103 | $ (339) | $ 764 | $ 1,910 | $ 1,037 | $ 596 | $ 278 | 62,400 | 281,600 | 337,600 |
| 2016 | $ 959 | $ 158 | $ 1,113 | $ (319) | $ 793 | $ 1,911 | $ 1,052 | $ 576 | $ 282 | 70,900 | 345,100 | 343,500 |
| 2017 | $ 947 | $ 158 | $ 1,124 | $ (302) | $ 822 | $ 1,927 | $ 1,070 | $ 571 | $ 287 | 79,000 | 405,600 | 349,500 |
| 2018 | $ 939 | $ 154 | $ 1,136 | $ (287) | $ 849 | $ 1,941 | $ 1,075 | $ 574 | $ 292 | 86,100 | 461,200 | 355,600 |
| 2019 | $ 928 | $ 155 | $ 1,149 | $ (274) | $ 875 | $ 1,958 | $ 1,105 | $ 556 | $ 296 | 92,600 | 514,100 | 361,800 |
| 2020 | $ 939 | $ 155 | $ 1,162 | $ (262) | $ 900 | $ 1,994 | $ 1,130 | $ 563 | $ 301 | 98,800 | 563,900 | 367,700 |
| 2021 | $ 953 | $ 103 | $ 1,177 | $ (254) | $ 923 | $ 1,979 | $ 1,132 | $ 542 | $ 305 | 104,600 | 609,600 | 373,600 |
| 2022 | $ 967 | $ 70 | $ 1,193 | $ (247) | $ 946 | $ 1,984 | $ 1,140 | $ 533 | $ 310 | 110,100 | 652,200 | 379,800 |
| 2023 | $ 981 | $ 60 | $ 1,210 | $ (241) | $ 969 | $ 2,010 | $ 1,160 | $ 535 | $ 315 | 115,300 | 692,700 | 385,800 |
| 2024 | $ 995 | $ 39 | $ 1,227 | $ (237) | $ 991 | $ 2,025 | $ 1,184 | $ 522 | $ 319 | 120,200 | 730,500 | 391,900 |
| 2025 | $ 1,009 | $ 33 | $ 1,245 | $ (233) | $ 1,012 | $ 2,054 | $ 1,201 | $ 529 | $ 324 | 125,100 | 766,600 | 398,000 |
| 2026 | $ 1,023 | $ 33 | $ 1,263 | $ (229) | $ 1,034 | $ 2,090 | $ 1,224 | $ 537 | $ 329 | 129,600 | 800,400 | 404,000 |
| 2027 | $ 1,037 | $ 34 | $ 1,281 | $ (227) | $ 1,054 | $ 2,125 | $ 1,247 | $ 545 | $ 333 | 133,900 | 831,200 | 410,100 |
| 2028 | $ 1,051 | $ 34 | $ 1,300 | $ (226) | $ 1,074 | $ 2,159 | $ 1,268 | $ 552 | $ 338 | 137,900 | 860,200 | 416,100 |
| 2029 | $ 1,065 | $ 34 | $ 1,318 | $ (225) | $ 1,093 | $ 2,192 | $ 1,290 | $ 560 | $ 343 | 141,700 | 887,700 | 422,200 |
| 2030 | $ 1,079 | $ 35 | $ 1,337 | $ (225) | $ 1,112 | $ 2,226 | $ 1,311 | $ 568 | $ 347 | 145,400 | 913,100 | 428,300 |
| 2031 | $ 1,093 | $ 35 | $ 1,356 | $ (225) | $ 1,130 | $ 2,259 | $ 1,331 | $ 576 | $ 352 | 148,800 | 936,700 | 434,400 |
| 2032 | $ 1,107 | $ 36 | $ 1,374 | $ (226) | $ 1,149 | $ 2,291 | $ 1,351 | $ 583 | $ 357 | 152,100 | 959,800 | 440,500 |
| 2033 | $ 1,121 | $ 36 | $ 1,393 | $ (227) | $ 1,167 | $ 2,324 | $ 1,372 | $ 591 | $ 361 | 155,400 | 982,000 | 446,700 |
| 2034 | $ 1,135 | $ 37 | $ 1,412 | $ (228) | $ 1,185 | $ 2,356 | $ 1,392 | $ 599 | $ 366 | 158,500 | 1,003,700 | 452,800 |
| 2035 | $ 1,149 | $ 37 | $ 1,431 | $ (229) | $ 1,202 | $ 2,389 | $ 1,412 | $ 606 | $ 371 | 161,600 | 1,024,500 | 458,900 |
| 2036 | $ 1,163 | $ 38 | $ 1,450 | $ (230) | $ 1,220 | $ 2,421 | $ 1,431 | $ 614 | $ 375 | 164,500 | 1,044,800 | 465,100 |
| 30 Yr NPV at 3% | $ 14,628 | $ 1,344 | $ 18,772 | $ (5,236) | $ 13,535 | $ 29,507 | $ 17,040 | $ 7,988 | $ 4,479 | 1,584,300 | 8,662,500 | 6,511,100 |
| 30 Yr NPV at 7% | $ 7,502 | $ 791 | $ 9,891 | $ (3,198) | $ 6,693 | $ 14,986 | $ 8,635 | $ 4,102 | $ 2,248 | 768,300 | 3,900,200 | 3,593,900 |

The calculations of cost per ton of each emission reduced under the Case 2 sensitivity divides the net present value of the annual costs assigned to each pollutant (Table 8A.3-8) by the net present value of the total annual reductions of each pollutant (Table 8A.3-8). The 30-year net present value of the costs associated with each pollutant, calculated with a three percent discount rate, are shown in Table 8A.3-8 as $8.0 billion for NOx+NMHC, $17.0 billion for PM, and $4.5 billion for SOx, with the total cost of the program estimated at $29.5 billion. The 30-year net present value, with a three percent discount rate, of emission reductions are estimated at 8.7 million tons of NOx+NMHC, 1.6 million tons of PM, and 6.5 million tons of SOx (see Table 8A.3-8). How these emissions reductions were developed is described in Section 8A.2 (see Table 8A.2-6).[J] The results of the cost per ton calculations are shown in Table 8A.3-9.

Table 8A.3-9
Aggregate Cost per Ton for the Case 2 Sensitivity
30-year Net Present Values at a 3% and 7% Discount Rate ($2002)

| Item | 3% discount rate | 7% discount rate | Source |
|---|---|---|---|
| Cost per Ton NOx+NMHC | $920 | $1,050 | Calculated |
| Cost per Ton PM | $10,800 | $11,200 | Calculated |
| Cost per Ton SOx | $690 | $630 | Calculated |

We have also calculated the cost per ton of emissions reduced in the year 2030 using the annual costs and emission reductions in that year alone. This number, shown in Table 8A.3-10, approaches the long-term cost per ton of emissions reduced.

Table 8A.3-10
Long-Term Cost per Ton of the Case 2 Sensitivity
Annual Values without Discounting ($2002)

| Pollutant | Long-Term Cost per Ton in 2030 |
|---|---|
| NOx+NMHC | $620 |
| PM | $9,000 |
| SOx | $810 |

[J] Note that the emissions reductions shown in Table 8A.3-8 are not identical to the reductions one would get using the inventories presented in Table 8A.2-6. The emissions inventories in Table 8A.2-6 are for land based nonroad engines only and do not include emissions associated with locomotive and marine engines. To make the comparison between the Case 2 $/ton and the NRT4 full program $/ton, the Case 2 locomotive and marine emissions reductions are included with the Case 2 nonroad land based emissions reductions. The Case 2 locomotive and marine emissions reductions would be identical to those under the NRT4 full program since nothing about the Case 2 sensitivity would impact emissions reductions from locomotive and marine engines. Therefore, the NRT4 full program locomotive and marine emissions reductions have been added to the Case 2 nonroad land based emissions reductions to arrive at the Case 2 emissions reductions shown in Table 8A.3-8.

## 8A.4 Summary of the Sensitivity Analyses Results

We present here a summary of the results of the Case 1 and Case 2 sensitivity analyses, and we compare these results to the NRT4 full engine and fuel program (i.e., the NRT4 Final Rule).

Table 8A.4-1 shows the emission reduction comparison between the NRT4 full program and the sensitivity cases for PM and NOx. As can be seen, the Case 1 sensitivity results in a decrease in both PM and NOx emissions reductions on the order of 35 to 40 percent. The Case 2 sensitivity results in an increase in PM reductions on the order of 10 percent and an increase in NOx reductions on the order of 20 percent.

Table 8A.4-1
Emissions Reduction* Comparison for Case 1 and Case 2 Sensitivity Analyses
30 Year Net Present Values at a 3% Discount Rate

| Baseline/Control Scenario | NOx+NMHC (tons) | Percent Relative to NRT4 FRM | PM (tons) | Percent Relative to NRT4 FRM |
|---|---|---|---|---|
| Nonroad Tier 4 Final Rule | 7,077,900 | - | 1,430,500 | - |
| Case 1 Sensitivity Analysis | 4,421,600 | -38% | 919,400 | -36% |
| Case 2 Sensitivity Analysis | 8,662,500 | 22% | 1,584,300 | 11% |

* See Tables 8.6-1, 8A.3-5, and 8A.3-8, respectively.

Table 8A.4-2 summarizes the results of the two sensitivity cases with respect to cost-effectiveness for NMHC+NOx, PM, and SOx, and compares these values to the final NRT4 program. As can be seen, the Case 1 sensitivity analysis results in an increase in the $/ton estimates for all pollutants. However, in all cases, these estimates are still within the range of previous mobile source control programs for NMHC+NOx and PM, and for SOx on the same order as stationary control programs for acid rain (see Tables VI.D-3, -4, and -5 of the preamble for this final rule). For the Case 2 sensitivity analysis, Table 8A.4-2 shows that the cost-effectiveness for NOx+NMHC and for PM are lower than for the final Tier 4 program, and for SOx the cost-effectiveness is the same as for the final Tier 4 program.

Table 8A.4-2
Comparison of Aggregate Cost per Ton Estimates: NRT4 Final Rule, Case 1 Sensitivity Analysis, and Case 2 Sensitivity Analysis
30-year Net Present Values at a 3 percent Discount Rate ($2002)

| Pollutant | Nonroad Tier 4 Final Rule | Case 1 Sensitivity Analysis | Case 2 Sensitivity Analysis |
|---|---|---|---|
| NOx+NMHC ($/ton) | $1,010 | $1,490 | $920 |
| PM ($/ton) | $11,200 | $15,800 | $10,800 |
| SOx ($/ton) | $690 | $870 | $690 |

# Appendix 8B: Fuel Volumes used throughout Chapter 8

The volumes in this Appendix were developed from the information contained in Section 7.1 of Chapter 7 of the RIA. Demand volumes are estimated for each EPA use category, including nonroad, locomotive, marine, and highway diesel fuel, and heating oil, for 2014. The 2014 estimated volumes of pipeline downgrade and highway diesel fuel spillover are apportioned to various EPA use categories depending on the regulatory scenario. By default, this analysis estimates the volume of fuel which must be desulfurized for supplying the overall demand of each EPA use category. The regulatory scenarios modeled for their volumes for this Chapter include the Final Rule Program and several sensitivity cases which are summarized here. For each case, the table which summarizes the 2014 volumes is listed along with the case description.

Final Rule Program:
- Period from 2007 to 2010 - NRLM must meet a 500 ppm sulfur cap standard. Small refiners are exempted and are assumed to produce high sulfur distillate and sell that fuel into the NRLM diesel fuel pool (Table 7.1.3-14).

- Period from 2010 to 2012 - nonroad must meet a 15 ppm sulfur cap standard and locomotive and marine must meet a 500 ppm sulfur cap. Small refiners are exempted and can sell exempted fuel into the nonroad diesel fuel pool, except for most of PADD 1, providing that they produce 500 ppm fuel (Table 7.1.3-17).

- Period from 2012 to 2014 - NRLM must meet a 15 ppm sulfur cap standard. Small refiners are exempted and can sell exempted fuel into the NRLM diesel fuel pool, except for most of PADD 1, providing that they produce 500 ppm fuel (Table 7.1.3-19).

- Period from 2014 and thereafter - The small refiner provisions have expired (Table 7.1.3-20).

NRLM to 500 ppm only:
- Period from 2007 to 2010 - Same as Final Rule Program above for the period 2007 to 2010 (Table 7.1.3-14).

- Period after 2010 - NRLM fuel remains at 500 ppm (Table 7.1.4-1).

Final Rule Program, EIA nonroad volumes:
- Same as Final Rule Program except that the nonroad volumes were developed using EIA information instead of using NONROAD (Tables 7.1.4-10, 7.1.4-11, 7.1.4-12, and 7.1.4-13 ).

All the volume streams in each case were apportioned into specific families of similar fuels depending on the quality of the specific volume stream and whether it was regulated under the NRLM Program. These fuel families and the streams which comprise them are summarized in the following table.

Fuel Families and the Fuels They Represent*

| Fuel Family | | | | | | |
|---|---|---|---|---|---|---|
| High Sulfur | Old 500 ppm | New 500 ppm | Old 15 ppm | Reprocessed Downgrade | New 15 ppm | Total Volume |
| High Sulfur (3000 ppm) distillate fuel including NRLM and heating oil<br><br>Small refiner fuel from 2007 to 2010 | 500 ppm diesel fuel meeting the Highway Diesel Fuel Program requirements | 500 ppm diesel fuel meeting the Nonroad Diesel Fuel Program requirements<br><br>Small refiner fuel from 2010 to 2014 | 15 ppm diesel fuel meeting the Highway Diesel Fuel Program requirements | Oversupply of downgrade into a market which must be reprocessed to 15 ppm | 15 ppm diesel fuel meeting the Nonroad Diesel Fuel Program requirements | Total of these various volumes. |

* California gallons are not included. “Affected” 500 ppm gallons are labeled here as “New 500 ppm” and “Affected” 15 ppm gallons are the summation of the columns labeled “Reprocessed Downgrade” and “New 15 ppm.”

The 2014 volumes are adjusted to estimate the volumes in each year from 2007 to 2040 using growth ratios compared to 2014 based on the growth rate factors in Tables 7.1.5-1 and 7.1.5-2.

Analyzing and categorizing the volumes in this fashion resulted in the development of the input volumes used in this chapter. For a more complete summary of how the volumes were calculated consult Section 7.1 of Chapter 7 of the RIA. The following tables summarize this information.

Table 8B-1
Nationwide Nonroad Volumes Under the NRT4 Final Rule Fuel Program

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 4,027 | 239 | 4,790 | 2,369 | - | - | 11,426 |
| 2008 | 584 | 179 | 8,406 | 2,526 | - | - | 11,695 |
| 2009 | 597 | 183 | 8,599 | 2,585 | - | - | 11,964 |
| 2010 | 255 | 673 | 4,014 | 2,643 | - | 6,189 | 12,233 |
| 2011 | - | 1,043 | 614 | 2,701 | - | 8,145 | 12,504 |
| 2012 | - | 1,066 | 528 | 2,760 | - | 8,420 | 12,774 |
| 2013 | - | 1,088 | 468 | 2,818 | - | 8,671 | 13,045 |
| 2014 | - | 463 | 199 | 2,941 | 68 | 9,645 | 13,316 |
| 2015 | - | - | - | 3,047 | 118 | 10,421 | 13,586 |
| 2016 | - | - | - | 3,107 | 121 | 10,626 | 13,854 |
| 2017 | - | - | - | 3,167 | 123 | 10,832 | 14,122 |
| 2018 | - | - | - | 3,227 | 125 | 11,037 | 14,390 |
| 2019 | - | - | - | 3,288 | 127 | 11,243 | 14,658 |
| 2020 | - | - | - | 3,352 | 130 | 11,448 | 14,926 |
| 2021 | - | - | - | 3,408 | 132 | 11,654 | 15,193 |
| 2022 | - | - | - | 3,468 | 134 | 11,859 | 15,461 |
| 2023 | - | - | - | 3,528 | 137 | 12,064 | 15,729 |
| 2024 | - | - | - | 3,588 | 139 | 12,270 | 15,997 |
| 2025 | - | - | - | 3,648 | 141 | 12,475 | 16,265 |
| 2026 | - | - | - | 3,708 | 144 | 12,679 | 16,531 |
| 2027 | - | - | - | 3,767 | 146 | 12,883 | 16,797 |
| 2028 | - | - | - | 3,827 | 148 | 13,088 | 17,063 |
| 2029 | - | - | - | 3,887 | 151 | 13,292 | 17,329 |
| 2030 | - | - | - | 3,946 | 153 | 13,496 | 17,595 |
| 2031 | - | - | - | 4,006 | 155 | 13,700 | 17,861 |
| 2032 | - | - | - | 4,066 | 158 | 13,904 | 18,127 |
| 2033 | - | - | - | 4,125 | 160 | 14,108 | 18,393 |
| 2034 | - | - | - | 4,185 | 162 | 14,312 | 18,659 |
| 2035 | - | - | - | 4,245 | 165 | 14,516 | 18,925 |
| 2036 | - | - | - | 4,304 | 167 | 14,720 | 19,191 |

Table 8B-2
Nationwide Locomotive Volumes Under the NRT4 Final Rule Fuel Program

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 968 | 45 | 1,141 | 539 | - | - | 2,694 |
| 2008 | 138 | 40 | 1,978 | 568 | - | - | 2,724 |
| 2009 | 140 | 40 | 2,005 | 576 | - | - | 2,761 |
| 2010 | 59 | 356 | 1,805 | 585 | - | - | 2,805 |
| 2011 | - | 591 | 1,671 | 596 | - | - | 2,858 |
| 2012 | - | 410 | 761 | 602 | - | 1,114 | 2,841 |
| 2013 | - | 278 | 99 | 607 | - | 1,925 | 2,909 |
| 2014 | - | 849 | 42 | 589 | - | 1,476 | 2,932 |
| 2015 | - | 1,266 | - | 577 | - | 1,154 | 2,956 |
| 2016 | - | 1,279 | - | 583 | - | 1,166 | 2,988 |
| 2017 | - | 1,291 | - | 589 | - | 1,177 | 3,015 |
| 2018 | - | 1,301 | - | 593 | - | 1,186 | 3,038 |
| 2019 | - | 1,313 | - | 599 | - | 1,197 | 3,067 |
| 2020 | - | 1,322 | - | 603 | - | 1,205 | 3,089 |
| 2021 | - | 1,329 | - | 606 | - | 1,212 | 3,104 |
| 2022 | - | 1,341 | - | 611 | - | 1,222 | 3,132 |
| 2023 | - | 1,353 | - | 617 | - | 1,233 | 3,160 |
| 2024 | - | 1,365 | - | 622 | - | 1,244 | 3,187 |
| 2025 | - | 1,378 | - | 628 | - | 1,256 | 3,218 |
| 2026 | - | 1,389 | - | 633 | - | 1,266 | 3,244 |
| 2027 | - | 1,400 | - | 638 | - | 1,276 | 3,270 |
| 2028 | - | 1,411 | - | 643 | - | 1,286 | 3,295 |
| 2029 | - | 1,422 | - | 648 | - | 1,296 | 3,321 |
| 2030 | - | 1,433 | - | 653 | - | 1,306 | 3,347 |
| 2031 | - | 1,444 | - | 658 | - | 1,316 | 3,373 |
| 2032 | - | 1,455 | - | 663 | - | 1,327 | 3,399 |
| 2033 | - | 1,466 | - | 668 | - | 1,337 | 3,425 |
| 2034 | - | 1,477 | - | 674 | - | 1,347 | 3,450 |
| 2035 | - | 1,488 | - | 679 | - | 1,357 | 3,476 |
| 2036 | - | 1,500 | - | 684 | - | 1,367 | 3,502 |

Table 8B-3
Nationwide Marine Volumes Under the NRT4 Final Rule Fuel Program

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 806 | 21 | 849 | 252 | - | - | 1,929 |
| 2008 | 190 | 23 | 1,476 | 266 | - | - | 1,955 |
| 2009 | 192 | 23 | 1,494 | 269 | - | - | 1,979 |
| 2010 | 81 | 269 | 1,380 | 273 | - | 0 | 2,003 |
| 2011 | - | 452 | 1,304 | 277 | - | 0 | 2,033 |
| 2012 | - | 292 | 636 | 280 | - | 851 | 2,059 |
| 2013 | - | 175 | 148 | 283 | - | 1,472 | 2,078 |
| 2014 | - | 222 | 62 | 281 | - | 1,605 | 2,103 |
| 2015 | - | 257 | - | 280 | - | 1,706 | 2,126 |
| 2016 | - | 259 | - | 283 | - | 1,722 | 2,146 |
| 2017 | - | 262 | - | 286 | - | 1,741 | 2,170 |
| 2018 | - | 266 | - | 290 | - | 1,768 | 2,203 |
| 2019 | - | 271 | - | 295 | - | 1,798 | 2,240 |
| 2020 | - | 202 | - | 299 | - | 1,818 | 2,266 |
| 2021 | - | 152 | - | 302 | - | 1,841 | 2,294 |
| 2022 | - | 154 | - | 307 | - | 1,871 | 2,331 |
| 2023 | - | 156 | - | 311 | - | 1,892 | 2,357 |
| 2024 | - | 158 | - | 315 | - | 1,917 | 2,389 |
| 2025 | - | 160 | - | 319 | - | 1,939 | 2,417 |
| 2026 | - | 162 | - | 323 | - | 1,964 | 2,448 |
| 2027 | - | 164 | - | 327 | - | 1,989 | 2,479 |
| 2028 | - | 166 | - | 331 | - | 2,014 | 2,510 |
| 2029 | - | 168 | - | 335 | - | 2,039 | 2,542 |
| 2030 | - | 170 | - | 339 | - | 2,065 | 2,573 |
| 2031 | - | 172 | - | 343 | - | 2,090 | 2,604 |
| 2032 | - | 175 | - | 347 | - | 2,115 | 2,635 |
| 2033 | - | 177 | - | 352 | - | 2,140 | 2,667 |
| 2034 | - | 179 | - | 356 | - | 2,165 | 2,698 |
| 2035 | - | 181 | - | 360 | - | 2,190 | 2,729 |
| 2036 | - | 183 | - | 364 | - | 2,215 | 2,760 |

Table 8B-4
Nationwide Nonroad Volumes Under the 500ppm NRLM Scenario

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 4,027 | 239 | 4,790 | 2,369 | - | - | 11,426 |
| 2008 | 584 | 179 | 8,406 | 2,526 | - | - | 11,695 |
| 2009 | 597 | 183 | 8,599 | 2,585 | - | - | 11,964 |
| 2010 | 255 | 936 | 8,400 | 2,643 | - | - | 12,233 |
| 2011 | - | 1,503 | 8,300 | 2,701 | - | - | 12,504 |
| 2012 | - | 1,535 | 8,479 | 2,760 | - | - | 12,774 |
| 2013 | - | 1,568 | 8,659 | 2,818 | - | - | 13,045 |
| 2014 | - | 1,600 | 8,839 | 2,877 | - | - | 13,316 |
| 2015 | - | 1,633 | 9,018 | 2,935 | - | - | 13,586 |
| 2016 | - | 1,665 | 9,196 | 2,993 | - | - | 13,854 |
| 2017 | - | 1,697 | 9,374 | 3,051 | - | - | 14,122 |
| 2018 | - | 1,729 | 9,552 | 3,109 | - | - | 14,390 |
| 2019 | - | 1,762 | 9,730 | 3,166 | - | - | 14,658 |
| 2020 | - | 1,794 | 9,907 | 3,224 | - | - | 14,926 |
| 2021 | - | 1,826 | 10,085 | 3,282 | - | - | 15,193 |
| 2022 | - | 1,858 | 10,263 | 3,340 | - | - | 15,461 |
| 2023 | - | 1,890 | 10,441 | 3,398 | - | - | 15,729 |
| 2024 | - | 1,923 | 10,619 | 3,456 | - | - | 15,997 |
| 2025 | - | 1,955 | 10,797 | 3,514 | - | - | 16,265 |
| 2026 | - | 1,987 | 10,973 | 3,571 | - | - | 16,531 |
| 2027 | - | 2,019 | 11,150 | 3,629 | - | - | 16,797 |
| 2028 | - | 2,051 | 11,326 | 3,686 | - | - | 17,063 |
| 2029 | - | 2,083 | 11,503 | 3,744 | - | - | 17,329 |
| 2030 | - | 2,115 | 11,679 | 3,801 | - | - | 17,595 |
| 2031 | - | 2,147 | 11,856 | 3,859 | - | - | 17,861 |
| 2032 | - | 2,179 | 12,032 | 3,916 | - | - | 18,127 |
| 2033 | - | 2,210 | 12,209 | 3,973 | - | - | 18,393 |
| 2034 | - | 2,242 | 12,386 | 4,031 | - | - | 18,659 |
| 2035 | - | 2,274 | 12,562 | 4,088 | - | - | 18,925 |
| 2036 | - | 2,306 | 12,739 | 4,146 | - | - | 19,191 |

Table 8B-5
Nationwide Locomotive Volumes Under the 500ppm NRLM Scenario

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 968 | 45 | 1,141 | 539 | - | - | 2,694 |
| 2008 | 138 | 40 | 1,978 | 568 | - | - | 2,724 |
| 2009 | 140 | 40 | 2,005 | 576 | - | - | 2,761 |
| 2010 | 59 | 211 | 1,950 | 585 | - | - | 2,805 |
| 2011 | - | 339 | 1,923 | 596 | - | - | 2,858 |
| 2012 | - | 342 | 1,942 | 602 | - | - | 2,886 |
| 2013 | - | 345 | 1,958 | 607 | - | - | 2,909 |
| 2014 | - | 347 | 1,973 | 611 | - | - | 2,932 |
| 2015 | - | 350 | 1,990 | 616 | - | - | 2,956 |
| 2016 | - | 354 | 2,011 | 623 | - | - | 2,988 |
| 2017 | - | 357 | 2,029 | 629 | - | - | 3,015 |
| 2018 | - | 360 | 2,044 | 633 | - | - | 3,038 |
| 2019 | - | 364 | 2,064 | 640 | - | - | 3,067 |
| 2020 | - | 366 | 2,079 | 644 | - | - | 3,089 |
| 2021 | - | 368 | 2,089 | 647 | - | - | 3,104 |
| 2022 | - | 371 | 2,108 | 653 | - | - | 3,132 |
| 2023 | - | 374 | 2,127 | 659 | - | - | 3,160 |
| 2024 | - | 378 | 2,145 | 664 | - | - | 3,187 |
| 2025 | - | 381 | 2,166 | 671 | - | - | 3,218 |
| 2026 | - | 385 | 2,184 | 677 | - | - | 3,244 |
| 2027 | - | 388 | 2,202 | 682 | - | - | 3,270 |
| 2028 | - | 391 | 2,220 | 688 | - | - | 3,295 |
| 2029 | - | 394 | 2,239 | 694 | - | - | 3,321 |
| 2030 | - | 398 | 2,258 | 699 | - | - | 3,347 |
| 2031 | - | 401 | 2,277 | 705 | - | - | 3,373 |
| 2032 | - | 404 | 2,296 | 711 | - | - | 3,399 |
| 2033 | - | 408 | 2,315 | 717 | - | - | 3,425 |
| 2034 | - | 411 | 2,334 | 723 | - | - | 3,450 |
| 2035 | - | 415 | 2,354 | 729 | - | - | 3,476 |
| 2036 | - | 418 | 2,374 | 735 | - | - | 3,502 |

Table 8B-6
Nationwide Marine Volumes Under the 500ppm NRLM Scenario

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 806 | 21 | 849 | 252 | - | - | 1,929 |
| 2008 | 190 | 23 | 1,476 | 266 | - | - | 1,955 |
| 2009 | 192 | 23 | 1,494 | 269 | - | - | 1,979 |
| 2010 | 81 | 142 | 1,508 | 273 | - | - | 2,003 |
| 2011 | - | 229 | 1,527 | 277 | - | - | 2,033 |
| 2012 | - | 232 | 1,546 | 280 | - | - | 2,059 |
| 2013 | - | 234 | 1,560 | 283 | - | - | 2,078 |
| 2014 | - | 237 | 1,579 | 286 | - | - | 2,103 |
| 2015 | - | 240 | 1,597 | 289 | - | - | 2,126 |
| 2016 | - | 242 | 1,612 | 292 | - | - | 2,146 |
| 2017 | - | 245 | 1,630 | 295 | - | - | 2,170 |
| 2018 | - | 249 | 1,654 | 300 | - | - | 2,203 |
| 2019 | - | 253 | 1,682 | 305 | - | - | 2,240 |
| 2020 | - | 256 | 1,702 | 309 | - | - | 2,266 |
| 2021 | - | 259 | 1,723 | 312 | - | - | 2,294 |
| 2022 | - | 263 | 1,751 | 317 | - | - | 2,331 |
| 2023 | - | 266 | 1,770 | 321 | - | - | 2,357 |
| 2024 | - | 270 | 1,794 | 325 | - | - | 2,389 |
| 2025 | - | 273 | 1,815 | 329 | - | - | 2,417 |
| 2026 | - | 276 | 1,838 | 333 | - | - | 2,448 |
| 2027 | - | 280 | 1,862 | 337 | - | - | 2,479 |
| 2028 | - | 283 | 1,885 | 342 | - | - | 2,510 |
| 2029 | - | 287 | 1,909 | 346 | - | - | 2,542 |
| 2030 | - | 290 | 1,932 | 350 | - | - | 2,573 |
| 2031 | - | 294 | 1,956 | 355 | - | - | 2,604 |
| 2032 | - | 297 | 1,979 | 359 | - | - | 2,635 |
| 2033 | - | 301 | 2,003 | 363 | - | - | 2,667 |
| 2034 | - | 305 | 2,026 | 367 | - | - | 2,698 |
| 2035 | - | 308 | 2,050 | 372 | - | - | 2,729 |
| 2036 | - | 312 | 2,073 | 376 | - | - | 2,760 |

Table 8B-7
Nationwide Nonroad Volumes Under the Case 1 Sensitivity

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 2,996 | 444 | 3,671 | 1,959 | - | - | 9,070 |
| 2008 | 592 | 153 | 6,373 | 2,067 | - | - | 9,186 |
| 2009 | 600 | 155 | 6,454 | 2,093 | - | - | 9,302 |
| 2010 | 253 | 66 | 3,086 | 2,141 | - | 3,873 | 9,419 |
| 2011 | - | - | 631 | 2,183 | - | 6,721 | 9,535 |
| 2012 | - | 358 | 531 | 2,188 | - | 6,574 | 9,651 |
| 2013 | - | 621 | 460 | 2,198 | - | 6,488 | 9,767 |
| 2014 | - | 262 | 194 | 2,275 | - | 7,153 | 9,884 |
| 2015 | - | - | - | 2,338 | - | 7,662 | 10,000 |
| 2016 | - | - | - | 2,366 | - | 7,751 | 10,116 |
| 2017 | - | - | - | 2,393 | - | 7,840 | 10,233 |
| 2018 | - | - | - | 2,420 | - | 7,929 | 10,349 |
| 2019 | - | - | - | 2,447 | - | 8,018 | 10,465 |
| 2020 | - | - | - | 2,474 | - | 8,107 | 10,581 |
| 2021 | - | - | - | 2,502 | - | 8,196 | 10,698 |
| 2022 | - | - | - | 2,529 | - | 8,285 | 10,814 |
| 2023 | - | - | - | 2,556 | - | 8,374 | 10,930 |
| 2024 | - | - | - | 2,583 | - | 8,464 | 11,047 |
| 2025 | - | - | - | 2,610 | - | 8,553 | 11,163 |
| 2026 | - | - | - | 2,638 | - | 8,642 | 11,279 |
| 2027 | - | - | - | 2,665 | - | 8,731 | 11,395 |
| 2028 | - | - | - | 2,692 | - | 8,820 | 11,512 |
| 2029 | - | - | - | 2,719 | - | 8,909 | 11,628 |
| 2030 | - | - | - | 2,746 | - | 8,998 | 11,744 |
| 2031 | - | - | - | 2,774 | - | 9,087 | 11,861 |
| 2032 | - | - | - | 2,801 | - | 9,176 | 11,977 |
| 2033 | - | - | - | 2,828 | - | 9,265 | 12,093 |
| 2034 | - | - | - | 2,855 | - | 9,354 | 12,210 |
| 2035 | - | - | - | 2,882 | - | 9,444 | 12,326 |
| 2036 | - | - | - | 2,910 | - | 9,533 | 12,442 |

Table 8B-8
Nationwide Locomotive Volumes Under the Case 1 Sensitivity

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 910 | 116 | 1,129 | 539 | - | - | 2,694 |
| 2008 | 162 | 37 | 1,957 | 568 | - | - | 2,724 |
| 2009 | 164 | 38 | 1,983 | 576 | - | - | 2,761 |
| 2010 | 70 | 426 | 1,741 | 569 | - | - | 2,805 |
| 2011 | - | 715 | 1,575 | 568 | - | - | 2,858 |
| 2012 | - | 410 | 732 | 590 | - | 1,155 | 2,886 |
| 2013 | - | 188 | 120 | 607 | - | 1,995 | 2,909 |
| 2014 | - | 455 | 50 | 584 | - | 1,842 | 2,932 |
| 2015 | - | 651 | - | 570 | - | 1,735 | 2,956 |
| 2016 | - | 658 | - | 576 | - | 1,754 | 2,988 |
| 2017 | - | 664 | - | 581 | - | 1,770 | 3,015 |
| 2018 | - | 669 | - | 586 | - | 1,783 | 3,038 |
| 2019 | - | 675 | - | 591 | - | 1,801 | 3,067 |
| 2020 | - | 680 | - | 595 | - | 1,813 | 3,089 |
| 2021 | - | 684 | - | 599 | - | 1,822 | 3,104 |
| 2022 | - | 690 | - | 604 | - | 1,838 | 3,132 |
| 2023 | - | 696 | - | 609 | - | 1,855 | 3,160 |
| 2024 | - | 702 | - | 614 | - | 1,871 | 3,187 |
| 2025 | - | 709 | - | 620 | - | 1,889 | 3,218 |
| 2026 | - | 714 | - | 625 | - | 1,904 | 3,244 |
| 2027 | - | 720 | - | 630 | - | 1,919 | 3,270 |
| 2028 | - | 726 | - | 635 | - | 1,934 | 3,295 |
| 2029 | - | 731 | - | 640 | - | 1,950 | 3,321 |
| 2030 | - | 737 | - | 645 | - | 1,965 | 3,347 |
| 2031 | - | 743 | - | 650 | - | 1,980 | 3,373 |
| 2032 | - | 748 | - | 655 | - | 1,995 | 3,399 |
| 2033 | - | 754 | - | 660 | - | 2,010 | 3,425 |
| 2034 | - | 760 | - | 665 | - | 2,025 | 3,450 |
| 2035 | - | 766 | - | 670 | - | 2,041 | 3,476 |
| 2036 | - | 771 | - | 675 | - | 2,056 | 3,502 |

Table 8B-9
Nationwide Marine Volumes Under the Case 1 Sensitivity

| Year | High Sulfur (million gallons) | Old 500 ppm (million gallons) | New 500 ppm (million gallons) | Old 15 ppm (million gallons) | Reprocessed Downgrade (million gallons) | New 15 ppm (million gallons) | Total Volume (million gallons) |
|---|---|---|---|---|---|---|---|
| 2007 | 757 | 67 | 853 | 252 | - | - | 1,929 |
| 2008 | 186 | 22 | 1,482 | 266 | - | - | 1,955 |
| 2009 | 188 | 22 | 1,499 | 269 | - | - | 1,979 |
| 2010 | 79 | 326 | 1,328 | 269 | - | - | 2,003 |
| 2011 | - | 551 | 1,210 | 271 | - | - | 2,033 |
| 2012 | - | 309 | 511 | 278 | - | 961 | 2,059 |
| 2013 | - | 133 | - | 283 | - | 1,662 | 2,078 |
| 2014 | - | 136 | - | 281 | - | 1,685 | 2,103 |
| 2015 | - | 140 | - | 280 | - | 1,706 | 2,126 |
| 2016 | - | 141 | - | 283 | - | 1,722 | 2,146 |
| 2017 | - | 143 | - | 286 | - | 1,742 | 2,170 |
| 2018 | - | 145 | - | 290 | - | 1,768 | 2,203 |
| 2019 | - | 147 | - | 295 | - | 1,798 | 2,240 |
| 2020 | - | 149 | - | 299 | - | 1,819 | 2,266 |
| 2021 | - | 151 | - | 302 | - | 1,841 | 2,294 |
| 2022 | - | 153 | - | 307 | - | 1,871 | 2,331 |
| 2023 | - | 155 | - | 311 | - | 1,892 | 2,357 |
| 2024 | - | 157 | - | 315 | - | 1,917 | 2,389 |
| 2025 | - | 159 | - | 319 | - | 1,939 | 2,417 |
| 2026 | - | 161 | - | 323 | - | 1,964 | 2,448 |
| 2027 | - | 163 | - | 327 | - | 1,989 | 2,479 |
| 2028 | - | 165 | - | 331 | - | 2,015 | 2,510 |
| 2029 | - | 167 | - | 335 | - | 2,040 | 2,542 |
| 2030 | - | 169 | - | 339 | - | 2,065 | 2,573 |
| 2031 | - | 171 | - | 343 | - | 2,090 | 2,604 |
| 2032 | - | 173 | - | 347 | - | 2,115 | 2,635 |
| 2033 | - | 175 | - | 352 | - | 2,140 | 2,667 |
| 2034 | - | 177 | - | 356 | - | 2,165 | 2,698 |
| 2035 | - | 179 | - | 360 | - | 2,190 | 2,729 |
| 2036 | - | 181 | - | 364 | - | 2,215 | 2,760 |

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