Chapter 7: Cost Per Ton

7.1 Cost Per Ton by Engine Type

7.1.1 Introduction

This chapter presents our estimate of the cost per ton of the various standards contained in this rule. The analysis relies on the costs estimates presented in Chapter 5 and the estimated lifetime emissions reductions using the information presented in Chapter 6. The chapter also presents a summary of the cost per ton of other recent EPA mobile source rulemakings for comparison purposes. Finally, this chapter presents the estimated costs and emission reductions as incurred over the first twenty years after the standards are implemented.

In calculating net present values that were used in our cost-per-ton estimates, we used a discount rate of 7 percent, consistent with the 7 percent rate reflected in the cost-per-ton analyses for other recent mobile source programs. OMB Circular A-94 requires us to generate benefit and cost estimates reflecting a 7 percent rate. Using the 7 percent rate allows us to make direct comparisons of cost-per-ton estimates with estimates for other, recently adopted, mobile source programs.

However, we consider that the cost and cost-per-ton estimates for future proposed mobile source programs could reflect a 3 percent rate. The 3 percent rate is in the 2 to 3 percent range recommended by the Science Advisory Board's Environmental Economics Advisory Committee for use in EPA social benefit-cost analyses, a recommendation incorporated in EPA's new *Guidelines for Preparing Economic Analyses (November 2000).* Therefore, we have also calculated the overall cost-effectiveness of today's rule based on a 3 percent rate to facilitate comparison of the cost-per-ton of this rule with future proposed rules which might use the 3 percent rate. The results using both a 3 percent and 7 percent discount rate are provided in this chapter.

7.1.2 Compression-Ignition Recreational Marine

As described in Chapter 5, several of the anticipated engine technologies will result in improvements in engine performance that go beyond emission control. While the cost estimates described in Chapter 5 do not take into account the observed value of performance improvements, these non-emission benefits should be taken into account in the calculation of cost-effectiveness. We believe that an equal weighting of emission and non-emission benefits is justified for those technologies which clearly have substantial non-emission benefits, namely electronic controls, fuel injection changes, turbocharging, and aftercooling for diesel engines and upgrading to electronic fuel injection for gasoline engines. For some or all of these technologies, a greater value for the non-emission benefits could likely be justified. This has the effect of halving the cost for those technologies in the cost-per-ton calculation. The cost-per-ton values in this chapter are based on this calculation methodology.

Although the rule will also result in PM reductions, we apply the total cost to the ozone forming gases (HC and NOx) presented in Chapter 6 for these calculations. The estimated per vessel costs presented in Chapter 5 change over time, with reduced costs in the long term. We have estimated both a near-term and long-term cost per ton as presented in Table 7.1-1 assuming a 7 percent discount rate. Table 7.1-2 presents the cost per tons results assuming a 3 percent discount rate..

Table 7.1-1
Estimated CI Recreational Marine Cost Per Ton of HC + NOx Reduced
(7 percent discount rate)

	Total Cost per Vessel (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vessel Cost ($/ton)
100 kW near-term	$231	0.24	$954
100 kW long-term	$141		$583
400 kW near-term	$396	0.97	$409
400 kW long-term	$175		$181
750 kW near-term	$1,118	1.32	$844
750 kW long-term	$374		$282
Composite near-term	$291	0.44	$669
Composite long-term	$155		$356

Table 7.1-2
Estimated CI Recreational Marine Cost Per Ton of HC + NOx Reduced
(3 percent discount rate)

	Total Cost per Vessel (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vessel Cost ($/ton)
100 kW near-term	$231	0.33	$703
100 kW long-term	$141		$429
400 kW near-term	$396	1.31	$301
400 kW long-term	$175		$133
750 kW near-term	$1,118	1.69	$661
750 kW long-term	$374		$221
Composite near-term	$291	0.59	$495
Composite long-term	$155		$263

7.1.3 Large Industrial SI Equipment

This section provides our estimate of the cost per ton of emissions reduced for large SI engines >19 kW. We have calculated cost per ton on the basis of exhaust HC plus NOx for gasoline, LPG and CNG engines and evaporative HC for gasoline engines. The analysis relies on the costs estimates in presented in Chapter 5 and the estimated net present value of the per vehicle lifetime emissions reductions (tons) presented in Chapter 6.

For the exhaust emission standards, the estimated per vehicle costs presented in Chapter 5 change over time, with reduced costs in the long term. We have estimated both a near-term and long-term cost per ton. In addition, we have estimated the cost per ton both with and without estimated fuel/maintenance savings. We have estimated the cost per ton for both the Phase 1 and Phase 2 standards, with the Phase 2 estimates incremental to Phase 1. The results of the cost per ton analysis for exhaust emission controls are presented in Tables 7.1.3-1 through 7.1.3-3 for gasoline, LPG and CNG engines assuming a 7 percent discount rate. The results of the cost-per-ton analysis for exhaust emission controls using a 3 percent discount rate follow in Tables 7.1.3-4 through 7.1.3-6.

Table 7.1-3
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(7 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$802	($3,247)	1.6	$496	($1,514)
Phase 1 long-term	$487			$301	($1,708)
Phase 2 near-term	$60	-	0.3	$175	-
Phase 2 long-term	$14			$41	-

Table 7.1-4
Estimated Large SI LPG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(7 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($4,557)	3.5	$158	($1,146)
Phase 1 long-term	$340			$97	($1,206)
Phase 2 near-term	$53	-	1.0	$56	-
Phase 2 long-term	$14			$15	-

Table 7.1-5
Estimated Large SI CNG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(7 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions* (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($1,648)	3.6	$153	($304)
Phase 1 long-term	$340			$94	($363)
Phase 2 near-term	$53	-	0.9	$61	-
Phase 2 long-term	$14			$16	-

* The reductions are calculated on the basis of NMHC+NOx for CNG engines only.

Table 7.1-6
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(3 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$802	($3,926)	2.0	$409	($1,573)
Phase 1 long-term	$487			$248	($1,733)
Phase 2 near-term	$60	-	0.4	$143	-
Phase 2 long-term	$14			$33	-

Table 7.1-7
Estimated Large SI LPG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(3 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($5,492)	4.2	$131	($1,162)
Phase 1 long-term	$340			$81	($1,212)
Phase 2 near-term	$53	-	1.2	$46	-
Phase 2 long-term	$14			$12	-

Table 7.1-8
Estimated Large SI CNG Engine >19 kW Cost Per Ton of Exhaust HC+NOx Reduced
(3 percent discount rate)

Standard	Total Cost per Vehicle (NPV)	Lifetime Fuel/ Maintenance Cost per Vehicle (NPV)	Lifetime Reductions* (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel/Maintenance Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel/Maintenance Savings ($/ton)
Phase 1 near-term	$552	($2,005)	4.4	$125	($321)
Phase 1 long-term	$340			$77	($369)
Phase 2 near-term	$53	-	1.1	$49	-
Phase 2 long-term	$14			$13	-

* The reductions are calculated on the basis of NMHC+NOx for CNG engines only.

For the evaporative emission standards, the estimated per vehicle costs are presented in Chapter 5. We have estimated the cost per ton both with and without the estimated fuel savings which occur as evaporative emissions are reduced. The results of the cost per ton analysis for evaporative emission controls for gasoline large SI engines >19 kW are presented in Table 7.1-9 based on both a 7 percent and 3 percent discount rate.

Table 7.1-9
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of Evaporative HC Reduced

Discount Rate	Total Cost per Vehicle (NPV)	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime Evaporative HC Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
7%	$13	($56)	0.16	$84	($279)
3%	$13	($69)	0.19	$68	($295)

7.1.4 Recreational Vehicle Exhaust Emissions

This section provides our estimate of the cost per ton of exhaust emissions reduced for recreational vehicles. We have calculated cost per ton on the basis of HC plus NOx for off-road

motorcycles and ATVs, and both HC and CO for snowmobiles. For snowmobiles, we have spread costs evenly over HC and CO reductions for purposes of calculating cost per ton. If reductions in other pollutants were included, the cost per ton estimates would be lower. The analysis relies on the per vehicle costs estimated in Chapter 5 and the estimated net present value of the per vehicle lifetime emissions reductions (tons) presented in Chapter 6. These cost per ton estimates do not include permeation control which is calculated separately for recreational vehicles, below.

The estimated per vehicle costs presented in Chapter 5 change over time, with reduced costs in the long term. We have estimated both a near-term and long-term cost per ton. In addition, we have estimated cost per ton both with and without estimated fuel savings. For snowmobiles, we have estimated the cost per ton for all three phases of standard incremental to the previous standards. The results of the analysis using the 7 percent discount rate are presented in Tables 7.1-10 through Table 7.1-12. The results using the 3 percent discount rate follow in Tables 7.1-13 through 7.1-15.

Table 7.1-10
Estimated Snowmobile Average Cost Per Ton of HC and CO Reduced
(7 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)		Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)		Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)	
			HC	CO	HC	CO	HC	CO
Phase 1 near-term	$73	($57)	0.40	1.02	$90	$40	$20	$10
Phase 1 long-term	$40				$50	$20	($20)	($10)
Phase 2 near-term	$131	($286)	0.10	n/a	$1,370	n/a	($1,610)	n/a
Phase 2 long-term	$77				$810	n/a	($2,190)	n/a
Phase 3 near-term	$89	($191)	n/a	0.25	n/a	$360	n/a	($410)
Phase 3 long-term	$54				n/a	$220	n/a	($550)

Table 7.1-11
Estimated ATV Average Cost Per Ton of HC + NOx Reduced
(7 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
near-term	$84	($24)	0.21	$400	$290
long-term	$42			$200	$90

Table 7.1-12
Estimated Off-highway Motorcycle Average Cost Per Ton of HC + NOx Reduced*
(7 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
near-term	$155	($48)	0.38	$410	$280
long-term	$95			$250	$120

* non-competition models only

Table 7.1-13
Estimated Snowmobile Average Cost Per Ton of CO Reduced
(3 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)		Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)		Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)	
			HC	CO	HC	CO	HC	CO
Phase 1 near-term	$73	($57)	0.50	1.25	$70	$30	$20	$10
Phase 1 long-term	$40				$40	$20	($20)	($10)
Phase 2 near-term	$131	($286)	0.12	n/a	$1,110	n/a	($1,305)	n/a
Phase 2 long-term	$77				$650	n/a	($1,770)	n/a
Phase 3 near-term	$89	($191)	n/a	0.31	n/a	$290	n/a	($330)
Phase 3 long-term	$54				n/a	$180	n/a	($450)

Table 7.1-14
Estimated ATV Average Cost Per Ton of HC + NOx Reduced
(3 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Phase 1 near-term	$84	($24)	0.26	$330	$240
Phase 1 long-term	$42			$160	$70

Table 7.1-15
Estimated Off-highway Motorcycle Average Cost Per Ton of HC + NOx Reduced*
(3 percent discount rate)

	Total Average Cost per Vehicle	Lifetime Average Fuel Cost per Vehicle (NPV)	Lifetime Average Reductions (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
near-term	$155	($48)	0.46	$340	$230
long-term	$95			$210	$100

* Non-competition models only

7.1.5 Recreational Vehicle Permeation Emissions

This section provides our estimate of the cost per ton of permeation emissions reduced for recreational vehicles. The analysis relies on the per vehicle costs estimated in Chapter 5 and the estimated lifetime emissions reductions (tons) presented in Chapter 6. All costs and emission reductions are discounted to the year of sale of the boats at a rate of 7 percent. Table 7.1-16 presents the cost per ton with and without consideration of the significant fuel savings that will result from evaporative emission control assuming a 7 percent discount rate. The cost per ton results assuming a 3 percent discount rate are presented in Table 7.1-17. As shown in these tables, the fuel savings more than offset the cost of the evaporative emission control technology.

Table 7.1-16
Estimated Cost Per Ton of HC Reduced (7 percent discount rate)

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles					
tank permeation	$2	$5	0.0125	$185	($178)
hose permeation	$4	$7	0.0182	$234	($129)
total	$7	$11	0.0307	$214	($149)
All Terrain Vehicles					
tank permeation	$2	$3	0.0070	$215	($148)
hose permeation	$1	$3	0.0082	$157	($206)
total	$3	$6	0.0152	$184	($179)
Off-Highway Motorcycles					
tank permeation	$1	$1	0.0041	$348	($15)
hose permeation	$2	$3	0.0096	$175	($188)
total	$3	$5	0.0137	$226	($137)

Table 7.1-17
Estimated Cost Per Ton of HC Reduced (3 percent discount rate)

	Total Cost Per Vehicle	Lifetime Fuel Savings Per Vehicle (NPV)	Lifetime Reductions Per Vehicle (NPV tons)	Discounted Per Vehicle Cost Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton)
Snowmobiles					
tank permeation	$2	$5	0.0144	$161	($202)
hose permeation	$4	$8	0.0209	$204	($159)
total	$7	$13	0.0353	$186	($177)
All Terrain Vehicles					
tank permeation	$2	$3	0.0086	$175	($188)
hose permeation	$1	$4	0.0100	$128	($235)
total	$3	$7	0.0186	$150	($213)
Off-Highway Motorcycles					
tank permeation	$1	$2	0.0047	$302	($61)
hose permeation	$2	$4	0.0110	$152	($211)
total	$3	$6	0.0157	$197	($166)

7.2 Cost Per Ton for Other Mobile Source Control Programs

Because the primary purpose of cost-effectiveness is to compare our program to alternative programs, we made a comparison between the cost per ton values presented in this chapter and the cost-effectiveness of other programs. Table 7.2-1 summarizes the cost effectiveness of several recent EPA actions for controlled emissions from mobile sources. These values show that the cost-effectiveness of the standards for this rulemaking fall within the range of these other programs.

Table 7.2-1
Cost-effectiveness of Previously Implemented
Mobile Source Programs (Costs Adjusted to 1997 Dollars)

Program	*$/ton*
Tier 2 vehicle/gasoline sulfur	1,340 - 2,260
2007 Highway HD diesel	1,458-1,867
2004 Highway HD diesel	212 - 414
Off-highway diesel engine	425 - 675
Tier 1 vehicle	2,054 - 2,792
NLEV	1,930
Marine SI engines	1,171 - 1,846
On-board diagnostics	2,313
Marine CI engines	24 - 176

The primary advantage of making comparisons to previously implemented programs is that their cost-effectiveness values were based on a rigorous analysis and are generally accepted as representative of the efficiency with which those programs reduce emissions. Unfortunately, previously implemented programs can be poor comparisons because they may not be representative of the cost-effectiveness of potential future programs. In the context of the Agency's rulemaking to revise the ozone and PM NAAQS[1], the Agency compiled a list of additional known technologies that may be considered in devising new emission reductions strategies.[1] Through this broad review, over 50 technologies were identified to reduce NOx, VOC, or PM. The cost-effectiveness of these technologies averaged approximately $5,000/ton for VOC, $13,000/ton for NOx, and $40,000/ton for PM.

In summary, given the array of controls that will have to be implemented to make progress toward attaining and maintaining the NAAQS, we believe that the weight of the evidence from alternative means of providing substantial NOx + NMHC emission reductions indicates that our program is cost-effective. This is true from the perspective of other mobile source control programs or from the perspective of other stationary source technologies that might be considered.

7.3 20-Year Cost and Benefit Analysis

The following section presents the year-by-year cost and emission benefits associated with the standards for the 20-year period after implementation of the standards. For the categories where we expect a reduction in fuel consumption due to the standards, the fuel savings

[1] This rulemaking was remanded by the D.C. Circuit Court on May 14, 1999. However, the analyses completed in support of that rulemaking are still relevant, since they were designed to investigate the cost-effectiveness of a wide variety of potential future emission control strategies.

are presented separately. The overall cost, incorporating the impact of the fuel savings is also presented.

Table 7.3-1 presents the year-by-year cost and emission benefits for the compression-ignition (CI) recreational marine requirements. (The numbers presented in Table 7.3-1 are not discounted.)

Table 7.3-1
Cost and Emission Benefits of the CI Recreational Marine Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	639	0	$7,806,010	$0	$7,806,010
2007	1,310	0	$8,365,319	$0	$8,365,319
2008	2,015	0	$8,573,839	$0	$8,573,839
2009	2,842	0	$9,413,530	$0	$9,413,530
2010	3,705	0	$9,637,035	$0	$9,637,035
2011	4,583	0	$5,213,411	$0	$5,213,411
2012	5,496	0	$5,176,672	$0	$5,176,672
2013	6,424	0	$5,290,764	$0	$5,290,764
2014	7,361	0	$4,958,052	$0	$4,958,052
2015	8,333	0	$5,062,713	$0	$5,062,713
2016	9,313	0	$5,167,682	$0	$5,167,682
2017	10,300	0	$5,272,652	$0	$5,272,652
2018	11,320	0	$5,377,623	$0	$5,377,623
2019	12,345	0	$5,482,592	$0	$5,482,592
2020	13,373	0	$5,587,562	$0	$5,587,562
2021	14,407	0	$5,692,532	$0	$5,692,532
2022	15,416	0	$5,797,503	$0	$5,797,503
2023	16,423	0	$5,902,472	$0	$5,902,472
2024	17,379	0	$6,007,442	$0	$6,007,442
2025	18,190	0	$6,112,413	$0	$6,112,413

Table 7.3-2 presents the sum of the costs and emission benefits over the twenty year period after the CI recreational marine requirements take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-2
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the CI Recreational Marine Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	181,174	0	$125.9	$0.0	$125.9
Discounted 20-year Value	79,294	0	$75.6	$0.0	$75.6
Annualized Value	7,485	0	$7.1	$0.0	$7.1

Table 7.3-3 presents the year-by-year cost and emission benefits for the large spark-ignition (SI) engine exhaust and evaporative requirements. (The numbers presented in Table 7.3-3 are not discounted.)

Table 7.3-3
Cost and Emission Benefits of the Large SI Engine Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2004	77,259	82,130	$88,806,711	$52,725,475	$36,081,236
2005	133,247	161,404	$91,185,462	$102,980,886	($11,795,424)
2006	187,149	239,617	$75,632,060	$152,926,193	($77,294,133)
2007	265,975	474,426	$84,493,379	$198,943,367	($114,449,988)
2008	329,756	678,940	$86,588,256	$242,829,040	($156,240,784)
2009	391,853	883,333	$68,943,347	$285,094,033	($216,150,686)
2010	451,604	1,076,572	$70,571,930	$325,741,703	($255,169,773)
2011	506,031	1,260,180	$72,200,513	$360,969,773	($288,769,260)
2012	542,932	1,427,950	$68,895,067	$379,398,454	($310,503,387)
2013	576,173	1,589,734	$70,414,812	$395,033,152	($324,618,340)
2014	606,048	1,730,897	$71,934,556	$408,985,187	($337,050,631)
2015	627,504	1,803,389	$73,454,300	$421,230,723	($347,776,423)
2016	646,713	1,866,433	$74,974,044	$432,435,409	($357,461,365)
2017	664,729	1,922,727	$76,493,788	$443,121,586	($366,627,798)
2018	681,633	1,972,496	$78,013,532	$453,291,958	($375,278,426)
2019	697,598	2,017,393	$79,533,276	$462,975,097	($383,441,821)
2020	712,638	2,059,586	$81,053,020	$471,991,726	($390,938,706)
2021	727,377	2,099,624	$82,572,765	$480,919,953	($398,347,188)
2022	741,822	2,137,602	$84,092,509	$489,742,176	($405,649,667)
2023	756,116	2,176,504	$85,612,253	$498,805,313	($413,193,060)

Table 7.3-4 presents the sum of the costs and emission benefits over the twenty year period after the large SI engine exhaust and evaporative requirements are to take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-4
Annualized Cost and Emission Benefits for the Period 2004-2023
due to the Large SI Engine Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	10,324,157	27,660,937	$1,565.5	$7,060.1	($5,494.7)
Discounted 20-year Value	4,945,366	12,631,259	$892.4	$3,433.5	($2,541.1)
Annualized Value	466,808	1,192,303	$84.2	$324.1	($239.9)

Table 7.3-5 presents the year-by-year cost and emission benefits for the snowmobile exhaust and permeation requirements. (The numbers presented in Table 7.3-5 are not discounted.)

Table 7.3-5
Cost and Emission Benefits of the Snowmobile Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	3,933	9,941	$6,583,529	$391,491	$6,192,038
2007	12,374	31,272	$13,546,439	$1,225,462	$12,320,977
2008	22,502	54,058	$13,183,508	$2,469,788	$10,713,720
2009	32,977	77,582	$13,455,182	$3,747,560	$9,707,622
2010	45,890	105,287	$38,933,137	$9,545,473	$29,387,664
2011	59,319	134,052	$38,685,132	$15,633,653	$23,051,479
2012	76,209	169,882	$51,957,587	$25,065,896	$26,891,691
2013	93,845	207,354	$52,701,157	$34,856,171	$17,844,987
2014	112,031	245,980	$45,309,024	$44,859,909	$449,115
2015	130,397	284,962	$44,402,290	$54,975,510	($10,573,219)
2016	148,455	323,196	$41,860,214	$65,045,977	($23,185,764)
2017	165,914	360,691	$41,738,365	$74,963,244	($33,224,879)
2018	181,480	394,252	$42,211,850	$84,545,886	($42,334,036)
2019	194,065	420,522	$42,677,612	$93,597,148	($50,919,536)
2020	204,737	442,187	$43,138,523	$102,179,264	($59,040,741)
2021	214,492	461,929	$43,138,523	$110,195,147	($67,056,624)
2022	222,824	478,985	$43,138,523	$116,664,922	($73,526,400)
2023	229,775	493,443	$43,138,523	$121,533,783	($78,395,261)
2024	235,195	504,816	$43,138,523	$125,181,189	($82,042,667)
2025	239,208	513,372	$43,138,523	$127,680,885	($84,542,362)

Table 7.3-6 presents the sum of the costs and emission benefits over the twenty year period after the exhaust and permeation requirements for snowmobiles take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-6
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the Snowmobile Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	2,625,622	5,713,763	$746.1	$1,214.4	($552.9)
Discounted 20-year Value	1,141,218	2,499,999	$379.9	$494.6	($145.8)
Annualized Value	107,723	235,983	$35.9	$46.7	($10.8)

Table 7.3-7 presents the year-by-year cost and emission benefits for the exhaust and permeation requirements for ATVs. (The numbers presented in Table 7.3-7 are not discounted.)

Table 7.3-7
Cost and Emission Benefits of the ATV Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	6,321	4,380	$42,463,856	$933,911	$41,529,945
2007	23,496	14,702	$79,998,942	$4,771,537	$75,227,405
2008	44,313	26,267	$76,517,949	$9,546,220	$66,971,729
2009	69,788	39,269	$70,286,998	$13,556,430	$56,730,568
2010	97,132	53,061	$65,302,237	$17,819,539	$47,482,698
2011	125,655	67,377	$56,379,476	$22,221,930	$34,157,546
2012	154,669	81,890	$52,441,476	$26,654,575	$25,786,901
2013	183,543	96,230	$52,441,476	$31,026,962	$21,414,514
2014	211,466	110,237	$52,441,476	$35,203,428	$17,238,048
2015	238,164	123,603	$52,441,476	$39,163,369	$13,278,107
2016	263,043	136,030	$49,999,146	$42,825,354	$7,173,792
2017	285,924	147,442	$47,556,815	$46,173,993	$1,382,822
2018	304,746	156,446	$47,556,815	$48,949,487	($1,392,672)
2019	316,793	161,571	$47,556,815	$50,819,932	($3,263,117)
2020	324,521	164,444	$47,556,815	$52,105,004	($4,548,189)
2021	329,849	166,533	$47,556,815	$52,985,302	($5,428,487)
2022	333,031	167,857	$47,556,815	$53,516,650	($5,959,835)
2023	335,389	168,858	$47,556,815	$53,912,720	($6,355,905)
2024	337,137	169,554	$47,556,815	$54,215,317	($6,658,502)
2025	338,413	170,055	$47,556,815	$54,442,855	($6,886,040)

Table 7.3-8 presents the sum of the costs and emission benefits over the twenty year period after the exhaust and permeation requirements for ATVs take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-8
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the ATV Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	4,323,393	2,225,806	$1,078.7	$710.8	$367.9
Discounted 20-year Value	1,951,668	1,014,866	$641.0	$325.3	$315.7
Annualized Value	184,224	95,796	$60.5	$30.7	$29.8

Table 7.3-9 presents the year-by-year cost and emission benefits for the off-highway motorcycle exhaust and permeation requirements. (The numbers presented in Table 7.3-9 are not discounted.

Table 7.3-9
Cost and Emission Benefits of the Off-Highway Motorcycle Requirements

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	3,085	2,330	$16,269,072	$633,450	$15,635,622
2007	9,742	7,398	$31,813,960	$2,061,773	$29,752,187
2008	18,028	13,408	$29,592,786	$3,878,230	$25,714,556
2009	27,409	20,236	$26,871,067	$5,903,201	$20,967,866
2010	37,325	27,463	$24,698,975	$8,016,233	$16,682,742
2011	47,542	34,917	$21,818,012	$10,166,886	$11,651,126
2012	57,733	42,364	$21,366,690	$12,282,632	$9,084,058
2013	67,631	49,612	$21,580,357	$14,311,527	$7,268,830
2014	77,400	56,774	$21,796,160	$16,290,860	$5,505,300
2015	86,976	63,810	$22,014,121	$18,207,111	$3,807,010
2016	96,030	70,471	$22,234,263	$19,981,626	$2,252,637
2017	103,553	76,047	$22,456,605	$21,421,145	$1,035,460
2018	108,707	79,882	$22,681,171	$22,409,671	$271,500
2019	112,249	82,490	$22,907,983	$23,107,057	($199,074)
2020	114,994	84,503	$23,137,063	$23,655,679	($518,616)
2021	117,320	86,207	$23,368,434	$24,122,020	($753,586)
2022	119,371	87,712	$23,602,118	$24,532,680	($930,562)
2023	121,137	89,007	$23,838,139	$24,886,440	($1,048,301)
2024	122,719	90,173	$24,076,521	$25,200,670	($1,124,149)
2025	124,218	91,284	$24,317,286	$25,496,728	($1,179,442)

Table 7.3-10 presents the sum of the costs and emission benefits over the twenty year period after the exhaust and permeation requirements for off-highway motorcycles take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-year period (assuming the seven percent discount rate) are also presented.

Table 7.3-10
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the Off-Highway Motorcycle Requirements

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 20-year Value	1,573,169	1,156,088	$470.4	$326.6	$143.9
Discounted 20-year Value	715,044	525,674	$268.9	$149.1	$119.8
Annualized Value	67,495	49,620	$25.4	$14.1	$11.3

Table 7.3-11 presents the year-by-year cost and emission benefits for all of the requirements. (The numbers presented in Table 7.3-11 are not discounted.)

Table 7.3-11
Cost and Emission Benefits of the Requirements for All Equipment Categories

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2004	77,259	82,130	$88,806,711	$52,725,475	$36,081,236
2005	133,247	161,404	$91,185,462	$102,980,886	($11,795,424)
2006	201,127	256,268	$148,754,528	$154,885,046	($6,130,518)
2007	312,897	527,798	$218,218,038	$207,002,139	$11,215,899
2008	416,614	772,673	$214,456,337	$258,723,278	($44,266,941)
2009	524,869	1,020,420	$188,970,125	$308,301,224	($119,331,100)
2010	635,656	1,262,383	$209,143,314	$361,122,948	($151,979,633)
2011	743,130	1,496,526	$194,296,545	$408,992,242	($214,695,697)
2012	837,039	1,722,086	$199,837,493	$443,401,557	($243,564,064)
2013	927,616	1,942,930	$202,428,566	$475,227,812	($272,799,246)
2014	1,014,306	2,143,888	$196,439,267	$505,339,384	($308,900,116)
2015	1,091,374	2,275,764	$197,374,901	$533,576,713	($336,201,812)
2016	1,163,554	2,396,130	$194,235,348	$560,288,366	($366,053,018)
2017	1,230,420	2,506,907	$193,518,225	$585,679,968	($392,161,743)
2018	1,287,886	2,603,076	$195,840,991	$609,197,002	($413,356,011)
2019	1,333,050	2,681,976	$198,158,277	$630,499,234	($432,340,957)
2020	1,370,263	2,750,720	$200,472,982	$649,931,673	($449,458,691)
2021	1,403,445	2,814,293	$202,329,067	$668,222,422	($465,893,354)
2022	1,432,464	2,872,156	$204,187,466	$684,456,428	($480,268,962)
2023	1,458,840	2,927,812	$206,048,201	$699,138,256	($493,090,055)
2024	1,482,773	2,980,012	$207,911,297	$712,465,187	($504,553,890)
2025	1,504,484	3,028,620	$209,776,777	$724,482,067	($514,705,289)

Table 7.3-12 presents the sum of the costs and emission benefits over the twenty-two year period after all of the requirements take effect, on both a non-discounted basis and a discounted basis (assuming a seven percent discount rate). The annualized cost and emission benefits for the twenty-two year period (assuming the seven percent discount rate) are also presented. (A twenty-two period is used in this aggregate analysis to cover the first twenty years of each of the standards which begins in 2004 for large SI engines and concludes in 2006 for the other categories of equipment.)

Table 7.3-12
Annualized Cost and Emission Benefits for the Period 2004-2025
due to the Requirements for All Equipment

	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings (Million $)	Fuel Savings (Million $)	Cost w/ Fuel Savings (Million $)
Undiscounted 22-year Value	22,106,425	44,300,504	$4,374.0	$11,072.1	($6,698.1)
Discounted 22-year Value	9,073,158	17,971,253	$2,176.7	$4,701.9	($2,525.2)
Annualized Value	789,161	1,561,958	$192.5	$410.1	($217.6)

Chapter 7 References

1.“Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Regional Haze Rule,” Appendix B, “Summary of control measures in the PM, regional haze, and ozone partial attainment analyses,” Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, July 17, 1997, Docket A-2000-01, Document II-A-77.