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 proposal. 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 proposed 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 anticipate that the primary cost and cost-per-ton estimates for future proposed mobile source programs will 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 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 proposed 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 7.1.2.-1 assuming a 7 percent discount rate. Table 7.1.2.-2 presents the cost per tons results assuming a 3 percent discount rate..

Table 7.1.2.-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	$475	0.24	$1,963
100 kW	long-term	$197		$814
400 kW	near-term	$384	1.13	$339
400 kW	long-term	$210		$185
750 kW	near-term	$707	2.12	$334
750 kW	long-term	$368		$174
Composite	near-term	$443	0.76	$560
Composite	long-term	$212		$277

Table 7.1.2.-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	$475	0.33	$1,450
100 kW	long-term	$197		$600
400 kW	near-term	$384	1.73	$222
400 kW	long-term	$210		$122
750 kW	near-term	$707	3.24	$218
750 kW	long-term	$368		$114
Composite	near-term	$443	1.15	$387
Composite	long-term	$212		$185

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 HC plus NOx for gasoline, LPG and CNG 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.

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/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 analysis 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 cost-per-ton results using a 3 percent discount rate follow in Tables 7.1.3.-4 through 7.1.3.-6.

Table 7.1.3.-1
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of 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	$787	($3,257)	1.9	$409	($1,283)
Phase 1 long-term	$507			$264	($1,428)
Phase 2 near-term	$51	-	0.4	$129	$129
Phase 2 long-term	$20			$51	$51

Table 7.1.3.-2
Estimated Large SI LPG Engine >19 kW Cost Per Ton of 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	$546	($4,554)	3.5	$156	($1,147)
Phase 1 long-term	$354			$101	($1,202)
Phase 2 near-term	$38	-	0.6	$61	$61
Phase 2 long-term	$14			$23	$23

Table 7.1.3.-3
Estimated Large SI CNG Engine >19 kW Cost Per Ton of 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	$546	($1,648)	3.6	$151	($306)
Phase 1 long-term	$354			$98	($359)
Phase 2 near-term	$38	-	0.5	$74	$74
Phase 2 long-term	$14			$27	$27

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

Table 7.1.3.-4
Estimated Large SI Gasoline Engine >19 kW Cost Per Ton of 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	$787	($3,940)	2.3	$336	($1,346)
Phase 1 long-term	$507			$217	($1,465)
Phase 2 near-term	$51	-	0.5	$105	$105
Phase 2 long-term	$20			$41	$41

Table 7.1.3.-5
Estimated Large SI LPG Engine >19 kW Cost Per Ton of 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	$546	($5,489)	4.2	$129	($1,171)
Phase 1 long-term	$354			$84	($1,217)
Phase 2 near-term	$38	-	0.8	$50	$50
Phase 2 long-term	$14			$19	$19

Table 7.1.3.-6
Estimated Large SI CNG Engine >19 kW Cost Per Ton of 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	$546	($2,005)	4.4	$124	($331)
Phase 1 long-term	$354			$80	($374)
Phase 2 near-term	$38	-	0.6	$60	$60
Phase 2 long-term	$14			$22	$22

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

7.1.4 Recreational Vehicles

This section provides our estimate of the cost per ton of 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 CO for snowmobiles. 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 5.2 and the estimated net present value of the per vehicle lifetime emissions reductions (tons) presented in Chapter 6.

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 ATVs and snowmobiles, 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 analysis using the 7 percent discount rate are presented in Tables 7.1.4.-1 through Table 7.1.4.-3. The results using the 3 percent discount rate follow in Tables 7.1.4.-4 through 7.1.4.-6.

Table 7.1.4.-1
Estimated Snowmobile Average Cost Per Ton of CO Reduced
(7 percent discount rate)

	Total Cost per Vehicle	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime 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	$55	-	1.18	$50	$50
Phase 1 long-term	$27			$20	$20
Phase 2 near-term	$216	($509)	0.32	$670	($910)
Phase 2 long-term	$125			$390	($1,200)

Table 7.1.4.-2
Estimated ATV Average Cost Per Ton of HC + NOx Reduced
(7 percent discount rate)

	Total Cost per Vehicle	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime 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	$60	($102)	0.88	$70	($50)
Phase 1 long-term	$38			$40	($70)
Phase 2 near-term	$52	-	0.09*	$550	$550
Phase 2 long-term	$28			$300	$300

* HC reductions only. We are not projecting a change in NOx emissions from the Phase 2 standard.

Table 7.1.4.-3
Estimated Off-highway Motorcycle Average Cost Per Ton of HC + NOx Reduced*
(7 percent discount rate)

	Total Cost per Vehicle	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime 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	$151	($98)	0.48	$310	$110
long-term	$94			$190	($10)

* non-competition models only

Table 7.1.4.-4
Estimated Snowmobile Average Cost Per Ton of CO Reduced
(3 percent discount rate)

	Total Cost per Vehicle	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime 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	$55	-	1.36	$40	$40
Phase 1 long-term	$27			$20	$20
Phase 2 near-term	$216	($621)	0.37	$580	($1,080)
Phase 2 long-term	$125			$330	($1,330)

Table 7.1.4.-5
Estimated ATV Average Cost Per Ton of HC + NOx Reduced
(3 percent discount rate)

	Total Cost per Vehicle	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime 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	$60	($131)	1.08	$60	($70)
Phase 1 long-term	$38			$40	($90)
Phase 2 near-term	$52	-	0.12*	$450	$450
Phase 2 long-term	$28			$240	$240

* HC reductions only. We are not projecting a change in NOx emissions from the Phase 2 standard.

Table 7.1.4.-6
Estimated Off-highway Motorcycle Average Cost Per Ton of HC + NOx Reduced*
(3 percent discount rate)

	Total Cost per Vehicle	Lifetime Fuel Cost per Vehicle (NPV)	Lifetime 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	$151	($124)	0.56	$270	$50
long-term	$94			$170	($50)

* Non-competition models only

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.

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

By comparing the cost per ton values presented in presented earlier in this chapter to those in Table 7.2-1, we can see that the cost effectiveness of the proposed standards for this rulemaking fall within the range of these other programs. It is true that some previous programs have been more cost efficient than the program we are proposing today. However, it should be expected that the next generation of standards will be more expensive than the last, since the least costly means for reducing emissions is generally pursued first.

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. Therefore, in evaluating the cost-effectiveness of our engine/diesel sulfur program, we also considered whether our proposal is cost-effective in comparison with potential future means of controlling emissions. In the context of the Agency's rulemaking which would have revised the ozone and PM NAAQS[n], the Agency compiled a list of additional known technologies that could be considered in devising new emission reductions strategies.[1] Through this broad review, over 50 technologies were identified that could 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. Although a $10,000/ton limit was actually used in the air quality analysis presented in the NAAQS revisions rule, these values clearly indicate that, not only are future emission control strategies likely to be more expensive (less cost-effective) than past strategies, but the cost-effectiveness of our engine/diesel sulfur program falls within the range of potential future strategies.

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 proposed 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 proposed standards for the 20-year period after implementation of the proposed standards. For the categories where we expect a reduction in fuel consumption due to the proposed standards, the fuel savings 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 proposed compression-ignition (CI) recreational marine requirements. (The numbers presented in Table 7.3.-1 are <u>not</u> discounted.)

[n] 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.

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

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	408	0	$2,951,157	$0	$2,951,157
2007	827	0	$3,312,159	$0	$3,312,159
2008	1,245	0	$3,396,992	$0	$3,396,992
2009	1,729	0	$3,646,513	$0	$3,646,513
2010	2,216	0	$3,735,360	$0	$3,735,360
2011	2,710	0	$2,314,047	$0	$2,314,047
2012	3,194	0	$2,367,961	$0	$2,367,961
2013	3,683	0	$2,230,244	$0	$2,230,244
2014	4,171	0	$2,191,180	$0	$2,191,180
2015	4,661	0	$2,238,896	$0	$2,238,896
2016	5,157	0	$2,290,857	$0	$2,290,857
2017	5,639	0	$2,338,809	$0	$2,338,809
2018	6,124	0	$2,386,760	$0	$2,386,760
2019	6,611	0	$2,434,712	$0	$2,434,712
2020	7,093	0	$2,482,664	$0	$2,482,664
2021	7,576	0	$2,530,616	$0	$2,530,616
2022	8,054	0	$2,578,568	$0	$2,578,568
2023	8,547	0	$2,626,520	$0	$2,626,520
2024	9,068	0	$2,674,472	$0	$2,674,472
2025	9,629	0	$2,722,423	$0	$2,722,423

Table 7.3.-2 presents the sum of the costs and emission benefits over the twenty year period after the CI recreational marine requirements are proposed 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.-2
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the Proposed 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	98,342	0	$53.5	$0.0	$53.5
Discounted 20-year Value	43,726	0	$31.4	$0.0	$31.4
Annualized Value	4,127	0	$3.0	$0.0	$3.0

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

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

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2004	73,472	150,685	$87,523,186	$49,094,701	$38,428,485
2005	129,407	298,527	$89,867,557	$96,402,876	($6,535,319)
2006	180,933	446,241	$74,189,576	$143,763,720	($69,574,144)
2007	254,759	753,861	$82,525,699	$189,779,490	($107,253,791)
2008	314,734	1,000,634	$84,571,791	$232,669,584	($148,097,793)
2009	371,693	1,235,609	$71,024,385	$273,576,196	($202,551,811)
2010	426,750	1,462,320	$72,702,127	$313,109,504	($240,407,377)
2011	478,793	1,675,145	$74,379,868	$349,996,101	($275,616,233)
2012	521,239	1,870,456	$71,570,190	$378,383,901	($306,813,711)
2013	554,784	2,052,958	$73,148,944	$398,274,918	($325,125,974)
2014	585,848	2,229,799	$74,727,698	$415,984,138	($341,256,440)
2015	612,293	2,362,438	$76,306,452	$431,606,591	($355,300,139)
2016	633,425	2,485,928	$77,885,207	$445,193,587	($367,308,380)
2017	653,387	2,566,367	$79,463,961	$457,797,866	($378,333,905)
2018	671,650	2,637,314	$81,042,715	$469,420,021	($388,377,306)
2019	688,861	2,702,977	$82,621,469	$480,293,483	($397,672,014)
2020	704,769	2,760,198	$84,200,223	$490,460,595	($406,260,372)
2021	719,823	2,811,641	$85,778,977	$500,194,473	($414,415,496)
2022	734,471	2,858,724	$87,357,732	$509,783,068	($422,425,336)
2023	748,711	2,901,826	$88,936,486	$519,236,885	($430,300,399)

Table 7.3.-4 presents the sum of the costs and emission benefits over the twenty year period after the large SI engine requirements are proposed 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 Proposed 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	10,059,802	37,263,648	$1,599.8	$7,145.0	($5,545.2)
Discounted 20-year Value	4,795,369	17,202,416	$904.3	$3,434.8	($2,530.5)
Annualized Value	452,649	1,623,789	$85.4	$324.2	($239.8)

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

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

Year	HC Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	10,949	28,488	$8,490,613	$0	$8,490,613
2007	21,937	57,072	$8,549,323	$0	$8,549,323
2008	32,848	85,448	$7,734,547	$0	$7,734,547
2009	44,140	114,808	$7,785,697	$0	$7,785,697
2010	57,886	151,436	$39,496,324	$6,636,300	$32,860,024
2011	71,954	188,906	$37,231,135	$13,258,300	$23,972,835
2012	85,448	224,873	$30,986,329	$19,660,300	$11,326,029
2013	98,859	260,626	$31,281,836	$26,031,500	$5,250,336
2014	111,904	295,402	$26,191,916	$32,094,700	($5,902,784)
2015	119,312	315,519	$25,003,879	$37,988,500	($12,984,621)
2016	126,527	335,157	$25,253,918	$43,918,600	($18,664,682)
2017	132,390	351,235	$25,506,457	$49,436,200	($23,929,743)
2018	137,680	365,808	$25,761,522	$54,772,300	($29,010,778)
2019	141,024	374,871	$26,019,137	$57,184,600	($31,165,463)
2020	143,752	382,265	$26,279,329	$59,141,500	($32,862,171)
2021	145,933	388,154	$26,542,122	$60,773,900	($34,231,778)
2022	147,725	393,054	$26,807,543	$62,147,800	($35,340,257)
2023	149,129	396,874	$27,075,618	$63,261,000	($36,185,382)
2024	150,308	400,077	$27,346,375	$64,179,500	($36,833,125)
2025	151,392	403,005	$27,619,838	$64,902,200	($37,282,362)

Table 7.3.-6 presents the sum of the costs and emission benefits over the twenty year period after the requirements for snowmobiles are proposed 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.-6
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the Proposed 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	2,081,097	5,513,078	$487.0	$715.4	($228.4)
Discounted 20-year Value	979,258	2,588,835	$255.6	$300.0	($44.4)
Annualized Value	92,435	244,368	$24.1	$28.3	($4.2)

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

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

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	29,157	52,512	$27,160,891	$4,292,200	$22,868,691
2007	100,482	165,812	$50,131,272	$14,731,200	$35,400,072
2008	171,247	281,480	$45,689,331	$24,938,100	$20,751,231
2009	255,542	401,518	$63,725,033	$36,446,300	$27,278,733
2010	341,496	520,318	$78,458,613	$47,393,500	$31,065,113
2011	426,374	639,187	$71,127,217	$58,026,100	$13,101,117
2012	515,980	762,621	$67,349,374	$69,170,200	($1,820,826)
2013	612,610	892,416	$60,745,130	$81,152,500	($20,407,370)
2014	701,796	1,013,664	$57,190,382	$91,989,700	($34,799,318)
2015	786,092	1,129,162	$56,810,044	$102,064,600	($45,254,556)
2016	863,212	1,235,362	$56,810,044	$111,098,900	($54,288,856)
2017	934,816	1,334,947	$56,810,044	$119,334,600	($62,524,556)
2018	999,821	1,425,240	$56,810,044	$126,656,200	($69,846,156)
2019	1,054,946	1,499,879	$54,369,424	$132,697,400	($78,327,976)
2020	1,095,016	1,548,389	$51,928,804	$136,876,300	($84,947,496)
2021	1,124,352	1,581,524	$51,928,804	$139,763,800	($87,834,996)
2022	1,148,062	1,608,835	$51,928,804	$142,059,500	($90,130,696)
2023	1,165,443	1,631,560	$51,928,804	$143,763,400	($91,834,596)
2024	1,179,935	1,651,047	$51,928,804	$145,032,800	($93,103,996)
2025	1,191,565	1,666,387	$51,928,804	$146,411,100	($94,482,296)

Table 7.3.-8 presents the sum of the costs and emission benefits over the twenty year period after the requirements for ATVs are proposed 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.-8
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the Proposed 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	14,697,944	21,041,860	$1,114.8	$1,873.9	($759.1)
Discounted 20-year Value	6,640,351	9,603,721	$629.8	$858.0	($228.3)
Annualized Value	626,803	906,525	$59.5	$81.0	($21.5)

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

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

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2006	3,202	2,250	$8,806,305	$691,900	$8,114,405
2007	9,491	6,704	$17,208,490	$2,036,100	$15,172,390
2008	16,459	11,600	$15,768,334	$3,495,800	$12,272,534
2009	23,879	16,832	$14,297,728	$5,024,800	$9,272,928
2010	31,288	22,063	$13,123,614	$6,519,700	$6,603,914
2011	38,820	27,392	$11,551,224	$8,010,200	$3,541,024
2012	46,025	32,505	$11,289,563	$9,406,100	$1,883,463
2013	53,114	37,549	$11,402,459	$10,753,600	$648,859
2014	60,067	42,510	$11,516,483	$12,050,500	($534,017)
2015	65,156	46,242	$11,631,648	$13,010,800	($1,379,152)
2016	69,060	48,936	$11,747,964	$13,713,700	($1,965,736)
2017	71,707	50,833	$11,865,444	$14,203,200	($2,337,756)
2018	73,763	52,303	$11,984,099	$14,582,700	($2,598,601)
2019	75,530	53,567	$12,103,940	$14,911,600	($2,807,660)
2020	76,986	54,608	$12,224,979	$15,184,400	($2,959,421)
2021	78,115	55,411	$12,347,229	$15,395,600	($3,048,371)
2022	79,014	56,053	$12,470,701	$15,566,100	($3,095,399)
2023	79,721	56,555	$12,595,408	$15,701,400	($3,105,992)
2024	80,289	56,961	$12,721,362	$15,812,500	($3,091,138)
2025	80,802	57,323	$12,848,576	$15,910,400	($3,061,824)

Table 7.3.-10 presents the sum of the costs and emission benefits over the twenty year period after the requirements for off-highway motorcycles are proposed 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.-10
Annualized Cost and Emission Benefits for the Period 2006-2025
due to the Proposed 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	1,112,488	788,197	$249.5	$222.0	$27.5
Discounted 20-year Value	521,170	369,020	$142.9	$104.7	$38.2
Annualized Value	49,195	34,833	$13.5	$9.9	$3.6

Table 7.3.-11 presents the year-by-year cost and emission benefits for all of the proposed requirements, excluding snowmobiles. (The numbers presented in Table 7.3.-11 are not discounted.) Snowmobiles have been excluded from this aggregate analysis because the focus of the proposed snowmobile controls is CO emissions, unlike the other categories where the focus of the proposed controls is HC and/or NOx emissions.

Table 7.3.-11
Cost and Emission Benefits of the Proposed Requirements
for All Equipment Categories covered by the Proposal (Excluding Snowmobiles)

Year	HC+NOx Benefits (tons)	CO Benefits (tons)	Cost w/o Fuel Savings	Fuel Savings	Cost w/ Fuel Savings
2004	73,472	150,685	$87,523,186	$49,094,701	$38,428,485
2005	129,407	298,527	$89,867,557	$96,402,876	($6,535,319)
2006	213,700	501,003	$113,107,928	$148,747,820	($35,639,892)
2007	365,559	926,377	$153,177,619	$206,546,790	($53,369,171)
2008	503,685	1,293,714	$149,426,447	$261,103,484	($111,677,037)
2009	652,843	1,653,959	$152,693,660	$315,047,296	($162,353,636)
2010	801,750	2,004,701	$168,019,714	$367,022,704	($199,002,990)
2011	946,697	2,341,724	$159,372,356	$416,032,401	($256,660,045)
2012	1,086,438	2,665,582	$152,577,088	$456,960,201	($304,383,113)
2013	1,224,191	2,982,923	$147,526,776	$490,181,018	($342,654,242)
2014	1,351,882	3,285,973	$145,625,743	$520,024,338	($374,398,595)
2015	1,468,202	3,537,842	$146,987,040	$546,681,991	($399,694,951)
2016	1,570,854	3,770,226	$148,734,072	$570,006,187	($421,272,115)
2017	1,665,549	3,952,147	$150,478,257	$591,335,666	($440,857,409)
2018	1,751,358	4,114,857	$152,223,617	$610,658,921	($458,435,304)
2019	1,825,948	4,256,423	$151,529,544	$627,902,483	($476,372,939)
2020	1,883,864	4,363,195	$150,836,670	$642,521,295	($491,684,625)
2021	1,929,866	4,448,576	$152,585,626	$655,353,873	($502,768,247)
2022	1,969,601	4,523,612	$154,335,804	$667,408,668	($513,072,864)
2023	2,002,422	4,589,941	$156,087,217	$678,701,685	($522,614,468)
2024	2,032,037	4,650,783	$157,839,878	$689,465,750	($531,625,872)
2025	2,058,727	4,706,660	$159,593,797	$700,292,336	($540,698,539)

Table 7.3.-12 presents the sum of the costs and emission benefits over the twenty-two year period after all of the requirements (excluding snowmobiles) are proposed 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-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 proposed 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 Proposed Requirements for All Equipment (Excluding Snowmobiles)

	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	29,579,850	69,744,333	$3,361.5	$11,006.2	($7,644.7)
Discounted 22-year Value	11,941,041	28,460,357	$1,688.7	$4,700.0	($3,011.2)
Annualized Value	1,037,257	2,476,552	$149.4	$410.6	($261.3)

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.