Chapter 11: Regulatory Alternatives

Adopting standards to reduce emissions requires consideration of a variety of alternative approaches. This rulemaking development effort includes consideration of the timing of emission standards, the level of stringency, the appropriate test procedures, among other things. In this chapter, we present a variety of alternatives that we considered in preparing this rulemaking. While these alternatives were not adopted as part of the final rule, they are discussed here with an analysis of the associated costs and emission reductions involved and our rationale for not adopting them.

11.1 Recreational Marine Diesel Engines

While developing the CI recreational marine engine standards we analyzed two alternative approaches. The first approach was to apply the draft European Commission recreational marine emission standards to CI recreational marine engines used in the United States. Another approach we considered was to implement the CI recreational marine engine standards on the same schedule as for commercial marine engines. These two alternative approaches are discussed below.

11.1.1 Harmonization with Draft EC Standards

Several manufacturers commented that we should finalize the emission standards proposed by the European Commission (EC) for CI recreational marine engines for our national standards. These emission levels are presented in Table 11.1-1. This table also presents the U.S. standards finalized today and average baseline emissions based on data presented earlier in Chapter 4 on engines for which we had data on both HC+NOx and PM.[1] Based on this data, we believe that the proposed European emissions standards for recreational marine diesel engines may not result in a decrease in emissions, and may even allow an increase in emissions from engines operated in the U.S. because current engines are already performing better than the proposed EC limits. Also, because the Clean Air Act directs us to set standards that “achieve the greatest degree of emission reduction achievable” given appropriate considerations, we do not believe it would be appropriate to finalize emission standards at the levels proposed by the European Commission.

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[1] If we include HC+NOx data from engine tests that did not include PM measurement, the HC+NOx average decreases to 8.6 g/kW-hr.

Table 11.1-1
EPA and Proposed European Standards Compared to Average Baseline Levels for CI Recreational Marine Emissions

Pollutant	EPA Standards g/kW-hr	Proposed EC Standards g/kW-hr	Baseline Emissions g/kW-hr
HC+NOx	7.2-7.5	9.8 NOx, 1.5 HC*	9.2
PM	0.2-0.4	1.4	0.2
CO	5.0	5.0	1.3

* HC increases slightly with increasing power rating.

We are not presenting an analysis of the cost per ton of emission reduction for this approach because we do not believe that it would result in emission reductions. However, the engine manufacturers would still need to incur the certification and compliance costs presented in Chapter 5. Therefore, setting a standard equal to the draft EC standards would likely result in costs with few or no benefits.

11.1.2 Earlier Implementation Dates Consistent with Commercial Marine

We believe that the emission-reduction strategies expected for land-based nonroad diesel engines and commercial marine diesel engines will also be applied to recreational marine diesel engines. Marine diesel engines are generally derivatives of land-based nonroad and highway diesel engines. Marine engine manufacturers and marinizers make modifications to the engine to make it ready for use in a vessel. These modifications can range from basic engine mounting and cooling changes to a restructuring of the power assembly and fuel management system. Because we anticipate that the same or similar technology will be used to meet the recreational and commercial marine standards, we considered including recreational marine engines in the commercial marine program with the same implementation dates.

Engine manufacturers commented that recreational marine engines need at least two years of lead time after the commercial marine standards to transfer technology from commercial marine engines to recreational marine engines and to stagger the need for manufacturers' research and development costs. We agree that this is necessary. In current production practices, the recreational marine engines are designed to operate at a higher power to weight ratio than commercial engines which requires development efforts specific to these engines. Although we believe that the same technology can be applied to recreational and commercial marine engines to reduce emissions, we recognize that individual development efforts will be required. In current practices, manufacturers stagger their development schedules to effectively use resources which include engineering hours and test cell time. If we were to require that recreational marine engines meet the new standards in the same year as commercial marine engines, manufacturers would likely need to double their research and development resources. We do not consider it practical for a manufacturer to do this in time for earlier standards, especially if the resources are only needed for two years. By allowing an additional two years of lead time, manufacturers are better able to stagger their development efforts.

The advantage of the earlier implementation dates would be to achieve emission reductions two years earlier. This would not likely affect the hardware costs discussed in Chapter 5, but would significantly increase the research and development costs if new people had to be hired and new facilities constructed. In fact, manufacturers would not likely have enough time to increase their research and development resources in time to meet earlier implementation dates. Therefore we are giving two years of additional lead time for recreational marine engines beyond the commercial marine implementation dates.

11.2 Large Industrial Spark-Ignition Engines

Of the several possibilities for Large SI engines, we are choosing one alternative over several others. For example, we are not analyzing the alternative of adopting only 2004 standards. Given the California certification data showing that some manufacturers are already achieving 2007 emission levels (with steady-state testing). This alternative would therefore clearly not meet the Clean Air Act direction to adopt the most stringent standards achievable.

Second, we are not analyzing a scenario of more stringent emission standards. The 2007 standards follow directly from available emission test data showing what level of emission control is achievable in that time frame. Any significant emission reductions beyond the 2007 standards would be appropriate to consider for a third tier of emission standards. Once manufacturers gain experience with the new emission-control technologies and the measurement procedures, additional information will be available to help us evaluate the relative costs and benefits of more stringent standards. Such information is not available today.

Third, we are not considering the approach of requiring forklifts to convert to battery power. We don’t believe this would be an appropriate policy under Clean Air Act section 213, as described in the Summary and Analysis of Comments. An analysis comparing the life-cycle costs and benefits of the two alternative power sources for forklifts would provide useful information to consumers interested in evaluating their available choices. However, such an analysis is outside the scope of this rulemaking.

The alternative we have chosen to analyze captures a common input from those commenting on the proposal. Manufacturers generally questioned the need, value, or cost-effectiveness of adopting emission procedures requiring transient engine operation. To evaluate this more carefully, we analyzed the scenario of adopting the 2007 standards based only on steady-state emission measurement. To assess this alternative, we have calculated the costs and emission reductions associated with adding the transient controls to an engine already meeting the 2007 standards with steady-state testing.

Estimating the costs of controlling transient emissions is straightforward, with two simplifying assumptions. First, we need to assume that the technology and costs associated with the 2004 standards presented in Chapter 5 are sufficient to achieve the 2007 standards with steady-state testing. The existing California certification data support this. Second, even though the 2007 cost estimates include an allowance for meeting diagnostic requirements and field-testing standards, in this analysis we assign the full estimated cost of meeting the 2007 standards to upgrading for transient control. The resulting estimated first-year cost of $27 per engine therefore somewhat overestimates the actual cost . This includes engineering time to improve calibrations with the existing hardware, so there are no variable costs under this scenario.

To estimate the emission reductions associated with the transient test procedure, we rely primarily on the transient adjustment factors described in Chapter 6. Applying the transient adjustment factor leads to increased emissions of about 0.77 g/hp-hr HC+NOx and 3 g/hp-hr CO. Factoring in the lifetime operating parameters from the NONROAD model leads to a discounted lifetime emission reduction per engine of 0.22 tons for HC+NOx and 0.76 tons for CO. Comparing costs and emission reductions yields an estimated cost of about $200 per ton HC+NOx. Estimated nationwide emission reductions after fully phasing in the emission standards are 17,000 tons HC, 36,000 tons NOx, and 188,000 tons CO. These figures represent the incremental benefit of adding transient test procedures for the Tier 2 standards.

This analysis supports the decision to adopt emission standards requiring control of emissions during transient operation.

11.3 Recreational Vehicle Exhaust Emission Standards

11.3.1 Off-highway Motorcycles

We are presenting an analysis of two alternatives to the 2.0 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative. The less stringent alternative we are presenting is a 4.0 g/km HC+NOx standard in the same time frame as the 2.0 g/km standard (50 and 100% phase-in for 2006 and 2007). We are finalizing this standard as an option to the 2.0 g/km standard with the provision that a manufacturer must certify all of their products, including machines that may otherwise meet the exemption for vehicles used solely for competition, to the 4.0 g/km standard. This alternative is numerically less stringent than the 2.0 g/km standard, but may actually result in more significant emission reductions than the final program since machines that may otherwise be exempt in the final program are included in the optional 4.0 g/km standard. Most competition off-highway motorcycles that could meet the competition exemption use high performance two-stroke engines that have HC levels significantly higher than the standard.

The second alternative we are presenting is the 2.0 g/km standard with an additional more stringent Phase 2 standard of 1.0 g/km phased in at 50 and 100% in 2009 and 2010. We proposed this alternative for ATVs, but not for off-highway motorcycles. It is clear from our analysis of technology, the current off-highway motorcycle market, and the comments received from manufacturers that four-stroke engines are technologically within reach for all off-highway motorcycle applications. While it is less clear, based on our analysis of technology and comments received from manufacturers and user groups it appears that direct fuel injection for two-stroke engines may also be within reach for some off-highway motorcycle applications. An analysis of the costs, emission reductions, costs per ton, and economic impacts of the alternatives are presented here. The methodology used for these analyses are the same as those described for the final program in the previous chapters.

11.3.1.1 Per Unit Costs

We have analyzed a less stringent standard of 4.0 g/km HC+NOx phased in at 50 and 100% in 2006 and 2007. The per unit average cost for this alternative is presented in Table 11.3.1-1 below. The average costs are based on a technology mix that includes the use of four-stroke engines and direct fuel injection for two-stroke engines. Because off-highway motorcycles have been using four-stroke engines for a many years and there is a significant number of these engines sold, the cost of using a four-stroke engine is less than the cost of using a direct fuel injection system with a two-stroke engine. Since we do not anticipate that any direct fuel injection two-stroke engines will be capable of meeting the final standard of 2.0 g/km HC+NOx, the resulting average cost for this alternative is somewhat higher than that of the final program, which we estimated at $158 per unit (see Chapter 5).

Table 11.3.1-1
Estimated Average Costs For Off-Highway Motorcycle Alternative 1 (4.0 g/km)

		Cost	Lifetime Fuel Savings (NPV)	Baseline	Control	Incremental Cost	Incremental Fuel Savings (NPV)
< 125 cc (31%)	4-stroke engine	$219	($140)	55%	85%	$66	$42
	Direct injection	$375	($140)	0%	15%	$56	$21
	compliance	$7	--	0%	100%	$7	--
	total	--	--	--	--	$129	$63
125 < 250 cc (27%)	4-stroke engine	$286	($140)	29%	85%	$160	$78
	Direct injection	$375	($140)	0%	15%	$56	$21
	compliance	$7	--	0%	100%	$7	--
	total	--	--	--	--	$223	$99
≥ 250 cc (42%)	4-stroke engine	$353	($140)	29%	85%	$198	$78
	Direct injection	$375	($140)	0%	15%	$56	$21
	compliance	$7	--	0%	100%	$7	--
	total					$71	$99
Near Term Composite Incremental Cost		--	--	--	--	$210	$88
Long Term Composite Incremental Cost		--	--	--	--	$127	$88

We have also analyzed an alternative that would include our final standard of 2.0 g/km plus a Phase 2 standard of 1.0 g/km that would be phased in at 50 and 100% in 2009 and 2010. This additional level of control would require R&D beyond that projected for the final 2.0 g/km standard and the incorporation of additional controls for four-stroke engines. We are projecting that at least half of off-highway motorcycle models would be equipped with catalysts in order to meet this level of stringency. The estimated average per unit costs for Phase 2 incremental to Phase 1 are provided in Table 11.3.1-2. We estimate that Phase 2 would cost about $70 incremental to Phase 1.

Table 11.3.1-2
Estimated Average Costs For Phase 2 Off-highway Motorcycles (Phase 2 = 1.0 g/km)
(Non-competition models only)

		Cost	Lifetime Fuel Savings (NPV)	Baseline	Control	Incremental Cost	Incremental Fuel Savings (NPV)
< 125 cc (37%)	4-stroke engine	$219	($140)	100%	100%	$0	$0
	pulse air	$39	$0	25%	75%	$19	$0
	R&D including recalibration	$15	$0	0%	100%	$15	$0
	Catalyst	$68	$0	0%	50%	$34	$0
	compliance	$1	--	0%	100%	$1	--
	total	--	--	--	--	$70	$0
125 < 250 cc (21%)	4-stroke engine	$286	($140)	100%	100%	$0	$0
	pulse air	$39	$0	0%	25%	$19	$0
	R&D including recalibration	$15	$0	0%	100%	$15	$0
	Catalyst	$68	$0	0%	50%	$34	$0
	compliance	$1	--	0%	100%	$1	--
	total	--	--	--	--	$70	$0
≥ 250 cc (42%)	4-stroke engine	$353	($140)	100%	100%	$0	$0
	pulse air	$39	$0	0%	25%	$19	$0
	R&D including recalibration	$15	$0	0%	100%	$15	$0
	Catalyst	$70	$0	0%	50%	$35	$0
	compliance	$1	--	0%	100%	$1	--
	total					$71	$0
Near Term Composite Incremental Cost		--	--	--	--	$70	$0
Long Term Composite Incremental Cost		--	--	--	--	$28	$0

11.3.1.2 Aggregate Cost Estimates

Based on the above per unit costs, we have estimated the aggregate costs for the two alternatives. The aggregate costs for Alternative 2 includes the costs for both phases of standards. The aggregate costs for the alternatives are provided in Table 11.3.1-3, along with the aggregate cost estimates for the final off-highway motorcycle program, which are estimated in Chapter 5. The fuel savings for both alternatives result from the switching of two-stroke to four-stroke engines. Alternative 1 also experiences fuel savings by the incorporation of competition machines into the program. Competition machines would either switch from two-stroke to four-stroke engines or use direct fuel injection with two-stroke engines. Direct fuel injection with two-stroke technology can result in similar fuel savings as converting from two-stroke to four-stroke engines.

Table 11.3.1-3
Summary of Annual Aggregate Costs and Fuel Savings (millions of dollars)

	2006	2010	2015	2020	2025
OHMC Final Program	$16.27	$24.24	$21.53	$22.63	$23.79
Alternative 1	$30.68	$46.56	$42.90	$45.09	$47.39
Alternative 2	$16.27	$34.25	$28.53	$29.99	$31.52
Fuel Savings (Alt 1)	$1.32	$14.13	$30.62	$39.05	$41.98
Fuel Savings (Alt 2)	$0.63	$7.23	$16.19	$21.03	$22.65

11.3.1.3 Emissions Reductions

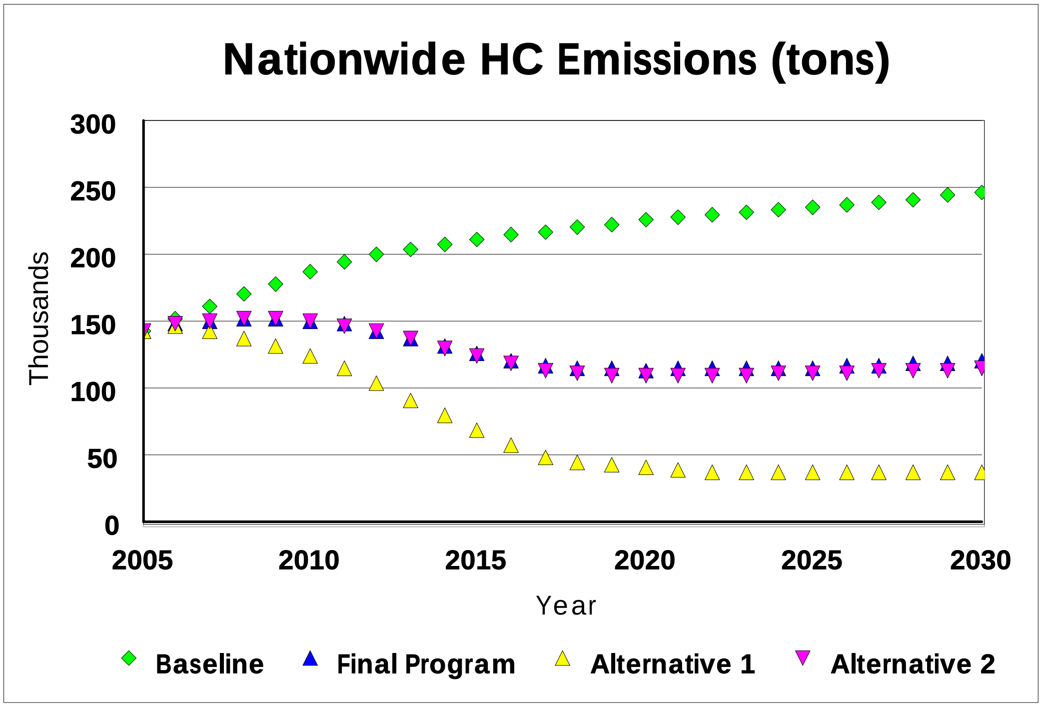
In Chapter 6, we estimated the emissions reductions for the final program. We have estimated the emissions reductions from both alternatives using the same methodology. We would expect NOx and CO to be similar under the various alternatives. The results for HC are shown in Table 11.3.1-4 and in the Figure 11.3.1-1. The majority of the HC emissions reductions occur due to switching those remaining two-stroke off-highway motorcycles over to four-stroke technology. We expect this to occur in each of the alternatives we have analyzed. Alternative 1 has significantly greater reductions than alternative 2 or the final program, even though the numerical standard is less stringent. This is due to the fact that alternative 1 includes all off-highway motorcycles. Machines that may otherwise qualify for the competition exemption make up 29-percent of off-highway motorcycle sales, and they tend to use high-performance two-stroke engines that emit very high levels of HC emissions. Controlling HC emissions from these machines to the alternative 1 standard of 4.0 g/km would result in significant reductions.

Table 11.3.1-4
Summary of HC Reductions (thousands of tons)

	2006	2010	2015	2020	2025
OHMC Final Program	3.1	36.3	84.1	111.1	120.0
Alternative 1	5.7	63.4	142.6	184.9	199.2
Alternative 2	3.1	36.8	86.6	115.4	124.8

Figure 11.3.1-1

Off-Highway Motorcycle HC Emissions Inventory



11.3.1.4 Cost Per Ton

Chapter 7 provides the cost per ton estimate for the final program. Using the same methodology, we have estimated the cost per ton of HC+NOx reduced for the two alternatives. The results are provided in Table 11.3.1-5. The results of Alternative 2 Phase 2 are based on the incremental change from 2.0 g/km to 1.0 g/km.

Table 11.3.1-5

Estimated Off-Highway Motorcycle Average

Cost Per Ton of HC + NOx Reduced (7 percent discount rate)

	Lifetime Reductions per Vehicle (NPV tons)	Discounted Per Vehicle Costs Per Ton without Fuel Savings ($/ton)	Discounted Per Vehicle Costs Per Ton with Fuel Savings ($/ton)
Final Program	0.38	$410	$280
Alternative 1	0.50	$420	$210
Alternative 2 Phase 1	0.38	$410	$280
Alternative 2 Phase 2*	0.02	$3,590	$3,590

* Phase 2 standards incremental to Phase 1

11.3.1.5 Economic Impacts Analysis

The human health and environmental benefits and economic costs of the regulatory alternatives for off-highway motorcycles are presented. The methodologies used to estimate the economic costs of these alternatives are discussed extensively in Chapter 9. We are presenting two alternatives to the 2.0 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative.

Table 11.3.1-6
Economic Costs of Alternative
Off-Highway Motorcycle Standards—Values in 2030 (millions of 2001$)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
OHM Final Program	$25.9	$25.0	$25.2	$0.2
Alternative 1	$33.1	$31.7	$46.4	$14.7
Alternative 2	$49.8	$46.6	$25.2	($21.5)

1 Economic costs or net economic costs shown in parenthesis. Additional important considerations, such as potential safety impacts discussed below, are not reflected in these cost estimates.

Table 11.3.1-7a
Economic Costs of Alternative Off-Highway Motorcycle Standards—Net Present Value 2002 through 2030 (millions of 2001$, using 3 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
OHM Final Program	$372.6	$358.9	$242.4	($116.5)
Alternative 1	$461.4	$441.1	$467.8	26.7
Alternative 2	$712.0	$663.1	$242.4	($420.7)

1 Economic costs or net economic costs shown in parenthesis.

Table 11.3.1-7b
Economic Costs of Alternative Off-Highway Motorcycle Standards—Net Present Value 2002 through 2030 (millions of 2001$, using 7 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
OHM Final Program	$214.3	$206.3	$120.6	($85.6)
Alternative 1	$261.6	$249.9	$232.5	($17.4)
Alternative 2	$408.6	$379.9	$120.6	($259.3)

1 Economic costs or net economic costs shown in parenthesis.

11.3.1.6 Discussion

Although alternative 1 is numerically less stringent than the final standard of 2.0 g/km HC+NOx, it would result in significant additional emissions reductions from the final program. These reductions are gained by the inclusion of machines that could otherwise qualify as vehicles used solely for competition into the program. The CAA requires that competition vehicles be exempt from emission regulations. Moreover, the 4.0 g/km standard would not otherwise meet the CAA requirements that standards achieve the greatest degree of emissions reduction achievable through use of available technology, taking cost, noise, energy, and safety into account. Therefore, this alternative cannot be considered as a replacement to the final program. However, the potential for significant emission reductions resulting from the control of competition machines is very desirable. That is why we are finalizing alternative 1 as an option to the 2.0 g/km HC+NOx standard in the final program. This option would result in the use of four-stroke engines and two-stroke engines equipped with direct fuel injection.

Alternative 2 would require manufacturers to achieve reductions beyond those required by the California off-highway motorcycle program. We believe that manufacturers would be required to use high levels of pulse air and would also need to use catalysts on some models. As discussed in Chapter 4, there are still concerns over the safety, durability and feasibility of the widespread use of catalysts on off-highway motorcycles. We are concerned that catalysts could pose safety threats from burns to individual riders as well as the potential for setting fires in the riding environment, which is frequently forests and grassy fields. There are also concerns over the ability of a catalyst to be able to physically survive in the very harsh environment that off-highway motorcycles frequently operate in. In general, we have concerns about the feasibility of many advanced emission control technologies with off-highway motorcycle applications. Off-highway motorcycles are exposed to dirt, dust, mud, water, rocks, etc. All of which make the use of relatively fragile technology such as electronic fuel injection and secondary air injection questionable. This alternative is based on the standards we proposed for ATVs but are not finalizing. As discussed in detail in the preamble for the Final Rule, we are not finalizing this level of control for ATVs due to concerns about the ability of manufacturers to meet the standards within the time frame proposed. These same concerns apply to off-highway motorcycles. We believe additional testing and analysis is needed before we can affirm the feasibility of Phase 2 standards.

11.3.2 All-terrain Vehicles

We are presenting an analysis of two alternatives to the 1.5 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative. The less stringent alternative we are presenting is a 2.0 g/km HC+NOx standard in the same time frame as the 1.5 g/km standard (50 and 100 % phase-in for 2006 and 2007). The second alternative we are presenting is the 2.0 g/km alternative with an additional more stringent Phase 2 standard of 1.0 g/km phased in at 50/100% in 2009/2010. We proposed but did not finalize two phases of standards for ATVs and the second alternative analyzed below is based on the proposed standards. It is clear from our analysis of technology, the current ATV market, and the comments received from manufacturers that 4-stroke engines are technologically within reach for all ATV applications. Therefore, the focus of the alternatives analysis is on what level of control to require from 4-stroke ATVs. An analysis of the costs, emissions reductions, costs per ton, and economic impacts of the alternatives are presented here. The methodology used for these analyses are the same as those described for the final program in the previous chapters. Also, the costs for the various technologies is presented in Chapter 5. Finally, a discussion of why these alternatives were not chosen for the Final Rule is provided in Section 11.3.2.6.

11.3.2.1 Per unit Costs

We have analyzed a less stringent standard of 2.0 g/km HC+NOx phased in at 50 and 100% in 2006 and 2007. The per unit average cost for this alternative is presented in Table 11.3.2-1 below. The average costs are based on a technology mix similar to that of the final 1.5 g/km standard, but with less reliance on reducing emissions from the 4-stroke engines through the use of recalibration and secondary air. This results in an average cost that is somewhat lower than that of the final program, which we estimated would cost $87 per unit (see Chapter 5).

Alternative 2 would require manufacturers to achieve reductions beyond those required by the California off-highway motorcycle program. We believe that manufacturers would be required to use high levels of pulse air and would also need to use catalysts on some models. As discussed in Chapter 4, there are still concerns over the safety, durability and feasibility of the widespread use of catalysts on off-highway motorcycles. We are concerned that catalysts could pose safety threats from burns to individual riders as well as the potential for setting fires in the riding environment, which is frequently forests and grassy fields. There are also concerns over the ability of a catalyst to be able to physically survive in the very harsh environment that off-highway motorcycles frequently operate in. In general, we have concerns about the feasibility of many advanced emission control technologies with off-highway motorcycle applications. Off-highway motorcycles are exposed to dirt, dust, mud, water, rocks, etc. All of which make the use of relatively fragile technology such as electronic fuel injection and secondary air injection questionable. This alternative is based on the standards we proposed for ATVs but are not finalizing. As discussed in detail in the preamble for the Final Rule, we are not finalizing this level of control for ATVs due to concerns about the ability of manufacturers to meet the standards within the time frame proposed. These same concerns apply to off-highway motorcycles. We believe additional testing and analysis is needed before we can affirm the feasibility of Phase 2 standards.

Table 11.3.2-1
Estimated Average Costs For a ATV Alternative 1 (2.0 g/km)

		Cost	Lifetime Fuel Savings (NPV)	% of use Baseline	% of use Control	Incremental Cost	Incremental Fuel Savings (NPV)
< 200 cc (15%)	4-stroke engine	$219	($124)	8%	100%	$202	($114)
	pulse air	$33	$0	0%	25%	$8	$0
	R&D for exhaust including recalibration	$16	$0	0%	50%	$8	$0
	permeation control	$3	($5)	0%	100%	$3	($5)
	compliance	$13	--	0%	100%	$13	--
	total	--	--	--	--	$234	($119)
> 200 cc (85%)	4-stroke engine	$349	($124)	93%	100%	$24	($9)
	pulse air	$27	$0	0%	25%	$7	$0
	R&D for exhaust including recalibration	$5	$0	0%	50%	$2	$0
	permeation control	$3	($5)	0%	100%	$3	($5)
	compliance	$12	--	0%	100%	$12	--
	total	--	--	--	--	$49	($13)
Near Term Composite Incremental Cost		--	--	--	--	$76	($29)
Long Term Composite Incremental Cost		--	--	--	--	$36	($29)

Table 11.3.2-2
Estimated Average Costs For ATV Alternative 2 (Phase 2 =1.0 g/km)

		Cost	Lifetime Fuel Savings (NPV)	% of use, Phase 1 = 2.0 g/km	% of use, Phase 2 = 1.0 g/km	Incremental Cost	Incremental Fuel Savings (NPV)
< 200 cc (15%)	4-stroke engine	$219	($124)	100%	100%	$0	$0
	pulse air	$33	$0	0%	50%	$16	$0
	R&D for exhaust including recalibration for Phase 2	$16	$0	0%	100%	$16	$0
	Catalyst	$68	$0	50%	100%	$34	$0
	compliance	$2	--	0%	100%	$2	--
	total	--	--	--	--	$68	$0
> 200 cc (85%)	4-stroke engine	$349	($124)	100%	100%	$0	$0
	pulse air	$27	$0	0%	50%	$14	$0
	R&D for exhaust including recalibration for Phase 2	$5	$0	0%	100%	$5	$0
	Catalyst	$70	$0	50%	100%	$35	$0
	compliance	$2	--	0%	100%	$2	--
	total	--	--	--	--	$54	$0
Near Term Composite Incremental Cost		--	--	--	--	$56	$0
Long Term Composite Incremental Cost		--	--	--	--	$30	$0

11.3.2.2 Aggregate Cost Estimates

Based on the above per unit costs, we have estimated the aggregate costs for the two alternatives. The aggregate costs for Alternative 2 includes the costs for both phases of standards. The aggregate costs for the alternatives are provided in Table 11.3.2-3, along with the aggregate cost estimates for the final ATV program, which are estimated in Chapter 5. The fuel savings result from switching from 2-stroke to 4-stroke engines and are the same for each alternative.

Table 11.3.2-3
Summary of Annual Aggregate Costs and Fuel Savings (millions of dollars)

	2006	2010	2015	2020	2025
ATV Final Program	$42.46	$65.30	$52.44	$47.56	$47.56
Alternative 1	$37.43	$57.11	$48.18	$43.29	$43.29
Alternative 2	$37.43	$102.58	$77.28	$72.39	$72.39
Fuel Savings	$0.93	$15.14	$36.22	$48.84	$51.00

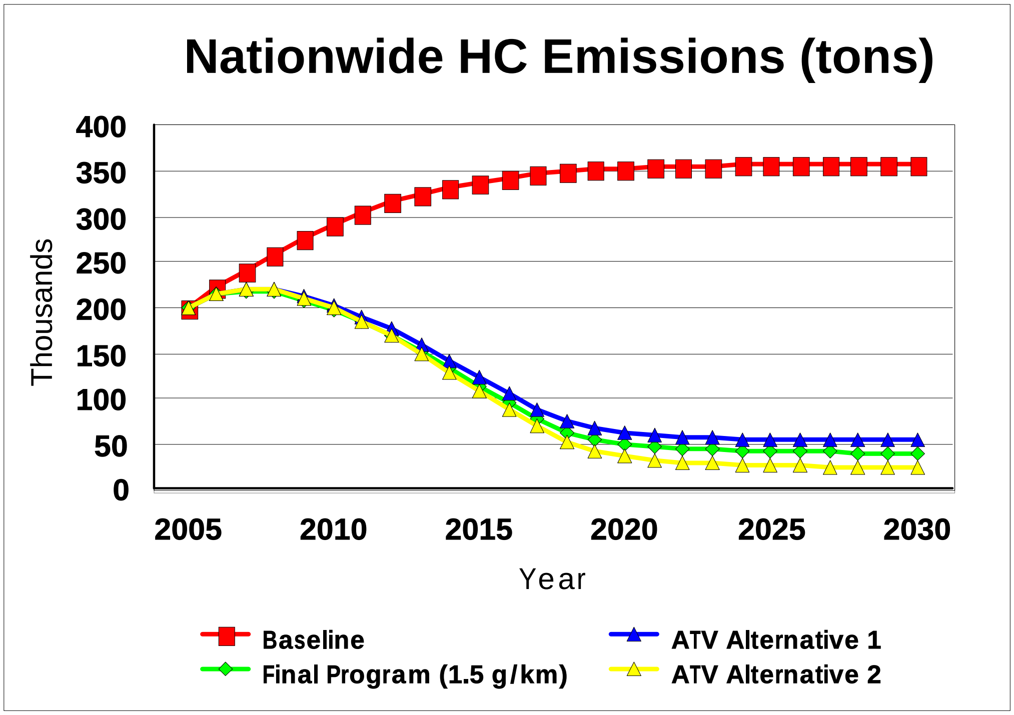
11.3.2.3 Emissions Reductions

In Chapter 6, we estimated the emissions reductions for the final program. We have estimated the emissions reductions for both alternatives using the same methodology. We would expect NOx and CO to be similar under the various alternatives. The results for HC are shown in Table 11.3.2-4 and in the following figure. The majority of the HC emissions reductions occur due to switching those remaining 2-stroke ATVs over to 4-stroke technology. The base emission factor is about 34 g/km for that 20 percent of the ATV fleet which is two-stroke and 1.8 g/km for the remaining 80 percent which are four stroke. Thus, even though eliminating the four strokes is significant the reductions from the four strokes is large as well. We expect this to occur in each of the alternatives we have analyzed.

Table 11.3.2-4
Summary of HC Reductions (thousands of tons)

	2006	2010	2015	2020	2025
ATV Final Program	6.2	92.4	225.0	304.1	315.5
Alternative 1	5.9	88.0	214.9	291.0	302.0
Alternative 2	5.9	91.1	230.4	317.0	331.0

Figure 11.3.2-1: ATV HC Emissions Inventory



11.3.2.4 Cost Per Ton

Chapter 7 provides the cost per ton estimates for the final program. Using the same methodology, we have estimated the cost per ton of HC+NOx reduced for the two alternatives. The results are provided in table 11.3.2-5. The results for Alternative 2 Phase 2 are based on the incremental change from 2.0 g/km to 1.0 g/km.

Table 11.3.2-5
Estimated ATV Average
Cost Per Ton of HC + NOx Reduced (7 percent discount rate)

	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)
Final Program	0.21	$400	$290
Alternative 1	0.20	$370	$250
Alternative 2 Phase 1	0.20	$370	$250
Alternative 2 Phase 2*	0.02	$2,700	$2,700

* Phase 2 standards incremental to Phase 1

11.3.2.5 Economic Impacts Analysis

The economic costs of the regulatory alternatives for ATVs are presented. The methodologies used to estimate economic costs of these alternatives are discussed extensively in Chapter 9. We are presenting two alternatives to the 1.5 g/km HC+NOx standard contained in the Final Rule, a less stringent and a more stringent alternative.

Table 11.3.2-6
Economic Costs of Alternative ATV Standards—Values in 2030 (millions of 2001$)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
ATV Final Program	$496.3	$491.9	$253.0	($238.9)
Alternative 1	$445.2	$441.7	$253.0	($188.6)
Alternative 2	$662.0	$654.1	$253.0	($401.0)

1 Economic costs or net economic costs shown in parenthesis.

Table 11.3.2-7a
Economic Costs of Alternative ATV Standards
Net Present Value 2002 through 2030
(millions of 2001$, using 3 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
ATV Final Program	$836.3	$829.2	$510.5	($318.7)
Alternative 1	$752.9	$747.0	$510.5	($236.5)
Alternative 2	$1,154.1	$1,140.5	$510.5	($630.0)

1 Economic costs or net economic costs shown in parenthesis.

Table 11.3.2-7b
Economic Costs of Alternative ATV Standards
Net Present Value 2002 through 2030
(millions of 2001$, using 7 percent discount rate)

Standard (HC/CO Reductions)	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[1]
ATV Final Program	$836.3	$829.2	$510.5	($318.7)
Alternative 1	$752.9	$747.0	$510.5	($236.5)
Alternative 2	$1,154.1	$1,140.5	$510.5	($630.0)

1 Economic costs or net economic costs shown in parenthesis.

11.3.2.6 Discussion

Alternative 1 would require only modest additional emissions reductions from 4-strokes, in general, and many models would meet the standard in their base configuration. In addition, this alternative is less stringent than the current California standard for ATVs. Most, if not all 4-stroke ATV models are certified to the California requirements. We received support for harmonizing standards with California and this level of control is feasible for 4-stroke equipped ATVs. Therefore, we do not believe that a standard less stringent than that contained in the California program would meet the basic criteria of the Clean Air Act which requires us to set a standard based on the greatest degree of emission reduction achievable. Our consideration of costs and economic impacts did not change our view that a 1.5 g/km standard was appropriate for ATVs.

Alternative 2 would require manufacturers to achieve reductions beyond those required in by the California program. We believe that manufacturers would be required to use a high level of pulse air and would also need to use catalyst on some ATV models. For our cost analysis above, we projected that catalysts would be used on half of all ATV models. This alternative is based on the standards we proposed for ATVs but are not finalizing. As discussed in detail in the preamble for the Final Rule, we are not finalizing this level of control due to concerns about the ability of manufacturers to meet the standards within time frame proposed. We believe additional testing and analysis is needed before we can affirm the feasibility of the Phase 2 standards.

11.3.3 Snowmobiles

While developing the final snowmobile emissions standards we analyzed four alternative sets of emissions standards, including options both less stringent and more stringent than the final standards. These alternatives are as follows:

Alternative 1 - keeping the Phase 1 standards indefinitely (i.e., not adopting Phase 2 or Phase 3 standards)

Alternative 2 - adopting the snowmobile manufacturers' recommended phase 2 standards in 2010 (which provide a 50% reduction in HC but keep the CO standard at the phase 1 level), with no Phase 3 standards

Alternative 3 - adopting Phase 2 standards in 2010 based on a large percentage of four-stroke engines; (70% HC/30% CO) reduction

Alternative 4 - adopting more stringent Phase 2 in 2010 which would require optimized advanced technology on every snowmobile; (85% HC/50% CO) reduction.

All of these alternatives were modeled assuming 100 percent compliance with the Phase 1 standards in 2006, whereas the final program includes a phase in with 50 percent compliance in 2006 and 100 percent compliance in 2007.

In addition to these alternative standards scenarios, we looked at what would happen if four-stroke engine technology cost 25 percent more than we originally projected in order to assess the sensitivity to four-stroke technology costs. This sensitivity analysis was done on Alternative 4. This scenario will be referred to as Alternative 5 for the remainder of this snowmobile section.

11.3.3.1 Per unit Costs

The per unit costs for the various alternatives are shown in Tables 11.3.3-1 through 11.3.3-5. Also included in these tables are the technology mixes we used for each of the alternatives. The per unit costs for alternative 1 (Phase 1 standards only) shown in Table 11.3.3-1 are identical to the per unit costs for Phase 1 of the final program. The near term composite incremental costs of all of the other alternatives can be compared to the near term incremental cost of $89 for Phase 3 of the final program, as shown in Table 5.2.3-22 in Chapter 5.

Table 11.3.3-1
Estimated Average Costs For Snowmobiles (Alternative 1 - Phase 1 only)

		Cost	Lifetime Fuel Savings	Baseline	Phase 1	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	engine modifications	$18	$0	0%	60%	$11	$0
	modified carburetor	$18	$0	0%	60%	$11	$0
	direct injection*	$328	($512)	7%	10%	$10	($15)
	electronic fuel injection	$175	$0	12%	15%	$5	$0
	4-stroke engine	$455	($512)	7%	10%	$14	($15)
	permeation control	$7	($10)	0%	100%	$7	($10)
	compliance	$12	--	0%	100%	$12	$0
	total	--	--	--	--	$69	($40)
≥ 500 cc (70%)	engine modifications	$25	$0	0%	60%	$15	$0
	modified carburetor	$24	$0	0%	60%	$14	$0
	direct injection*	$295	($1,139)	7%	10%	$9	($34)
	electronic fuel injection	$119	$0	12%	15%	$4	$0
	4-stroke engine	$770	($1,139)	7%	10%	$23	($34)
	permeation control	$7	($10)	0%	100%	$7	($10)
	compliance	$12	$0	0%	100%	$12	$0
	total	--	--	--	--	$84	($78)
Near Term Composite Incremental Cost		--	--	--	--	$80	($67)
Long Term Composite Incremental Cost		--	--	--	--	$47	($67)

Table 11.3.3-2
Estimated Average Costs For Snowmobiles (Alternative 2 - Phase 2 HC standards with Phase 1 CO standards)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	30%	$12	$0
	direct injection*	$328	($512)	10%	35%	$82	($128)
	electronic fuel injection	$175	$0	15%	20%	$9	$0
	4-stroke engine	$455	($512)	10%	15%	$23	($26)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$128	($154)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	30%	$12	$0
	direct injection*	$295	($1,139)	10%	35%	$74	($285)
	electronic fuel injection	$119	$0	15%	20%	$6	$0
	4-stroke engine	$770	($1,139)	10%	15%	$39	($57)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$132	($342)
Near Term Composite Incremental Cost		--	--	--	--	$131	($286)
Long Term Composite Incremental Cost		--	--	--	--	$77	($286)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 11.3.3-3
Estimated Average Costs For Snowmobiles (Alternative 3 - Four-stroke based Phase 2 Standards)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	25%	$10	$0
	direct injection*	$328	($512)	10%	10%	$0	$0
	electronic fuel injection	$175	$0	15%	65%	$87	$0
	4-stroke engine	$455	($512)	10%	60%	$228	($256)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$327	($256)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	25%	$10	$0
	direct injection*	$295	($1,139)	10%	10%	$0	$0
	electronic fuel injection	$119	$0	15%	65%	$60	$0
	4-stroke engine	$770	($1,139)	10%	60%	$385	($570)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$457	($570)
Near Term Composite Incremental Cost		--	--	--	--	$418	($476)
Long Term Composite Incremental Cost		--	--	--	--	$260	($476)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 11.3.3-4
Estimated Average Costs For Snowmobiles
(Alternative 4 - Phase 2 Standards based on broad application of advanced technology)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	0%	$12	$0
	direct injection*	$328	($512)	10%	10%	$0	$0
	electronic fuel injection	$175	$0	15%	90%	$131	$0
	4-stroke engine	$455	($512)	10%	90%	$364	($410)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$497	($410)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	0%	$	$0
	direct injection*	$295	($1,139)	10%	10%	$0	$0
	electronic fuel injection	$119	$0	15%	90%	$90	$0
	4-stroke engine	$770	($1,139)	10%	90%	$616	($911)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$718	($911)
Near Term Composite Incremental Cost		--	--	--	--	$652	($760)
Long Term Composite Incremental Cost		--	--	--	--	$410	($760)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

Table 11.3.3-5
Estimated Average Costs For Snowmobiles (Alternative 4 with 25% higher 4-stroke costs)

		Cost	Lifetime Fuel Savings	Phase 1	Phase 2	Incremental Cost	Incremental Fuel Savings
< 500 cc (30%)	pulse air/recalibration	$41	$0	0%	0%	$12	$0
	direct injection*	$328	($512)	10%	10%	$0	$0
	electronic fuel injection	$218	$0	15%	90%	$164	$0
	4-stroke engine	$569	($512)	10%	90%	$455	($410)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$621	($410)
≥ 500 cc (70%)	pulse air/recalibration	$41	$0	0%	0%	$	$0
	direct injection*	$295	($1,139)	10%	10%	$0	$0
	electronic fuel injection	$149	$0	15%	90%	$112	$0
	4-stroke engine	$963	($1,139)	10%	90%	$770	($911)
	certification	$2	--	0%	100%	$2	$0
	total	--	--	--	--	$894	($911)
Near Term Composite Incremental Cost		--	--	--	--	$812	($760)
Long Term Composite Incremental Cost		--	--	--	--	$512	($760)

* Direct injection costs are an average of the air-assisted and pump assisted system costs.

11.3.3.2 Aggregate Cost Estimates

Based on the above per unit costs, we have estimated the aggregate costs for the alternatives. The aggregate costs for the alternatives are presented in Table 11.3.3-6, along with the aggregate cost estimates for the final snowmobile program, which are estimated in Chapter 5. The fuel savings result in varying degrees of switching from current two-stroke technology to direct injection two-stroke and four-stroke technology.

Table 11.3.3-6
Summary of Annual Snowmobile Aggregate Costs and Fuel Savings (millions of dollars)

	2006	2010	2015	2020	2025
Final program	$6.58	$37.55	$41.91	$41.56	$41.56
Alternative 1	$13.17	$12.07	$11.08	$11.73	$11.73
Alternative 2	$13.17	$38.99	$28.65	$30.32	$30.32
Alternative 3	$13.17	$98.99	$70.03	$74.13	$74.13
Alternative 4	$13.17	$148.68	$104.08	$110.17	$110.17
Alternative 5	$13.17	$182.23	$127.25	$134.69	$134.69
Fuel savings (Final program)	$0.78	$11.81	$58.23	$103.00	$123.66
Fuel Savings (Alt 1)	$0.78	$4.31	$9.13	$12.33	$13.51
Fuel Savings (Alt 2)	$0.78	$8.81	$38.59	$66.73	$79.60
Fuel Savings (Alt 3)	$0.78	$11.81	$58.23	$103.00	$123.66
Fuel Savings (Alt 4)	$0.78	$16.31	$87.68	$157.40	$189.75
Fuel Savings (Alt 5)	$0.78	$16.31	$87.68	$157.40	$189.75

11.3.3.3 Emissions Reductions

In Chapter 6, we estimated the emissions reductions for the final program. We have estimated the emissions reductions for the alternatives using the same methodology. The results for HC are shown in Table 11.3.3-7 and in Figure 11.3.3-1, while the results for CO are shown in Table 11.3.3-8 and in Figure 11.3.3-2.

As can be seen in Tables 11.3.3-7 and 11.3.3-8, there are cases where the emissions reductions for a given pollutant are different for different alternatives even though the numerical limits for that pollutant are the same for those alternatives. For example, the final program and Alternative 2 would both require 50 percent reductions in HC, but the HC reductions shown in Table 11.3.3-7 are different for these two options. The reason for this difference in HC reductions is that under these two options the CO limits are different. Under the final program the CO limit would require a 50 percent reduction in CO, while in Alternative 2 the CO reductions would only be 30 percent. This difference in CO limits results in the need for a different technology mix being needed under the two alternatives. The more aggressive application of technology needed under the final program to meet the CO limit has the effect of producing somewhat higher HC reductions. Similarly, the different HC limits for Alternatives 1 through 3 result in different technology mixes for the these alternatives. These different technology mixes result in different CO reductions for each alternative even though the CO limits are the same for all three alternatives. This can be seen in Tale 11.3.3-8.

Table 11.3.3-7
Summary of Snowmobile HC Reductions (thousands of tons)

	2006	2010	2015	2020	2025
Final Program	4.0	42.9	123.3	196.1	230.4
Alternative 1	7.9	44.9	98.4	135.1	148.5
Alternative 2	7.9	47.3	114.2	165.2	185.6
Alternative 3	7.9	52.1	146.8	227.6	262.4
Alternatives 4 and 5	7.9	55.8	172.4	276.4	322.4

Table 11.3.3-8
Summary of Snowmobile CO Reductions (thousands of tons)

	2006	2010	2015	2020	2025
Final Program	9.9	105.3	285.0	442.2	513.4
Alternative 1	19.9	112.7	246.6	338.7	372.3
Alternative 2	19.9	116.2	270.1	383.6	427.7
Alternative 3	19.9	120.1	296.6	436.8	493.1
Alternatives 4 and 5	19.9	123.1	317.4	476.8	544.0

Figure 11.3.3-1 Snowmobile HC Emissions Inventory

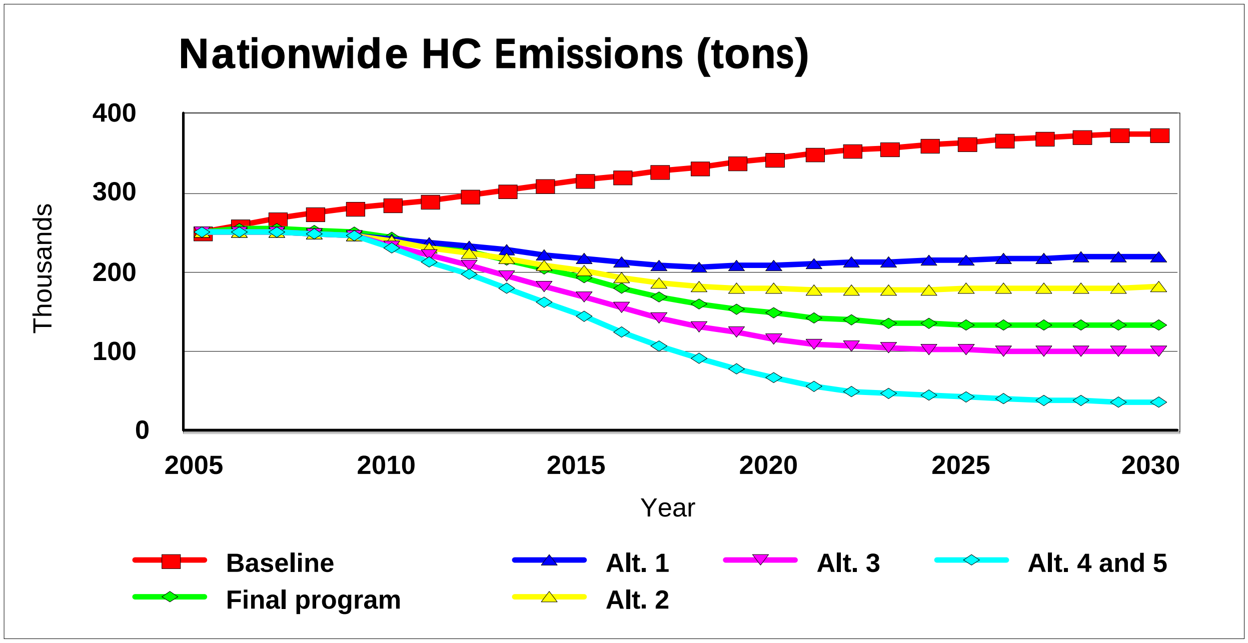
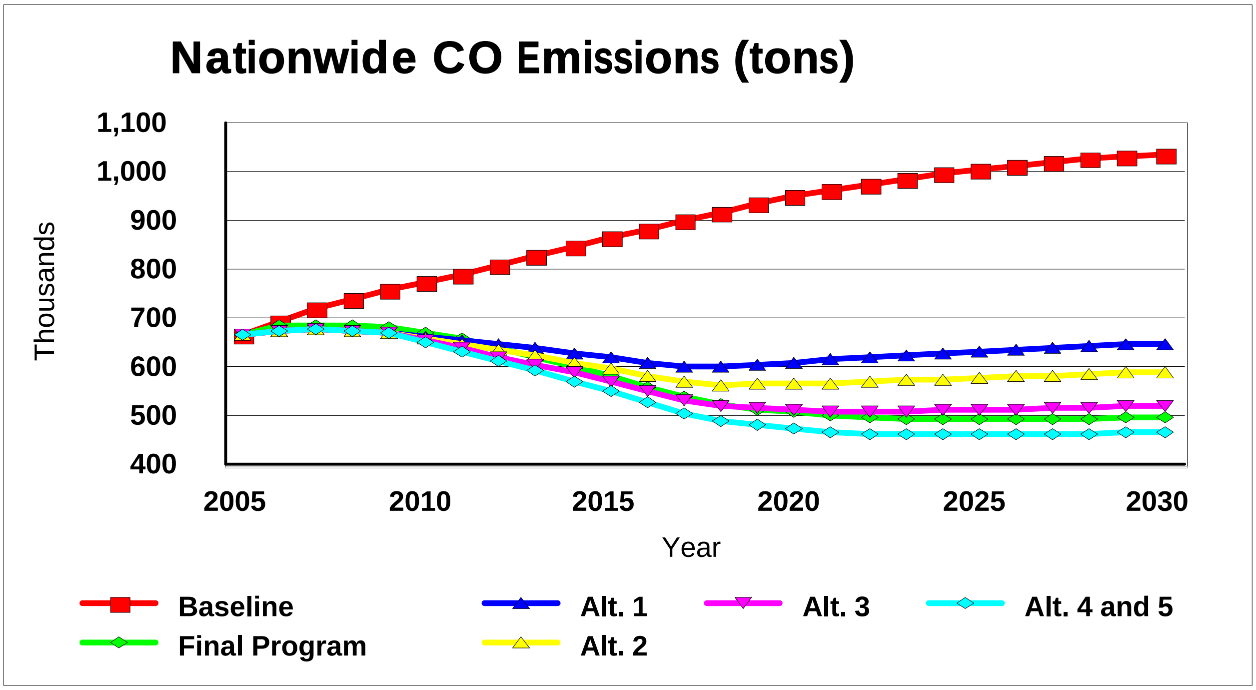


Figure 11.3.3-2 Snowmobile CO Emissions Inventory



11.3.3.4 Cost Per Ton

Chapter 7 provides the cost per ton estimates for the final program. Using the same methodology, we have estimated the cost per ton of HC and CO reduced for the alternatives, as shown in Table 11.3.3-9. The results for alternative 1 (Phase 1 standards only) are shown first. All other scenarios, including the final program, are base on the incremental change from the Phase 1 standards to whatever Phase 2 standards are considered in the particular scenario.

Table 11.3.3-9
Estimated Snowmobile Average Cost per Ton of HC and CO Reduced
(7 percent discount rate)

	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)	
	HC	CO	HC	CO	HC	CO
Alternative 1	0.40	1.02	$90	$40	$20	$10
Final Program[c]	n/a	0.25	n/a	$360	n/a	($410)
Alternative 2[a]	0.10	n/a	$1,370	n/a	($1,610)	n/a
Alternative 3[a]	0.28	n/a	$1,480	n/a	($210)	n/a
Alternative 4[a]	0.49	0.50	$670	650	($110)	($110)
Alternative 5[a,b]	0.49	0.50	$840	$810	($50)	($50)

a. Shown based on incremental change from Phase 1 standards.
b. Alternative 4 with 25% higher 4-stroke cost.
c. Shown based on incremental change from Phase 2 standards

11.3.3.5 Economic Impacts Discussion

The economic costs of the regulatory alternatives for snowmobiles are presented. Net social costs (or gains) of the alternatives in the year 2030 are shown on Table 11.3.3-10, while the net present value of these costs through 2030 are reflected on Tables 11.3.3-11a and 11.3.3-11b. The methodologies used to estimate the economic costs of these alternatives are discussed extensively in Chapter 9. Each of the alternatives, is modeled based on a 30 percent reduction in HC and CO, respectively during Phase 1 of the regulation.

Table 11.3.3-10
Economic Costs of Alternative Snowmobile Standards—Values in 2030[1,3] (millions of 2001$)

Scenario	**Engineering Costs**	**Economic Costs (Surplus Losses)**	**Fuel Efficiency Cost Savings**	**Economic Gains or Costs[2]**
Alternative 1	$11.7	$11.6	$18.2	$6.6
Alternative 2	$30.3	$29.8	$88.0	$58.2
Final Program	$43.1	$41.9	$135.0	$93.1
Alternative 3	$74.1	$70.5	$134.5	$64.0
Alternative 4	$111.2	$102.1	$204.3	$102.2
Alternative 5[4]	$134.7	$122.7	$204.3	$81.6

1. Assumes the final program Phase 1 standards as the first phase in each alternative
2. Economic costs or net economic costs shown in parenthesis.
3. Dollar values are rounded to the nearest 10 million.
4. Same standards as Alternative 4, but assumes a 25% increase in the cost of a 4-stroke engine.

Table 11.3.3-11a
Economic Costs of Alternative Snowmobile Standards—Net Present Value 2002 through 2030[1] (millions of 2001$, using 3 percent discount rate)

Scenario	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[2]
Alternative 1	$183.7	$182.1	$174.7	($7.4)
Alternative 2	$426.9	$418.9	$697.7	$278.8
Final Program	$569.6	$553.1	$999.6	$446.5
Alternative 3	$987.6	$885.0	$1,046.3	$161.3
Alternative 4	$1,450.1	$1,335.0	$1,569.3	$234.3
Alternative 5[3]	$1,763.8	$1,591.8	$1,569.3	($22.5)

1. Assumes the final program Phase 1 standards as the first phase in each alternative
2. Economic costs or net economic costs shown in parenthesis.
3. Same standards as Alternative 4, but assumes a 25% increase in the cost of a 4-stroke engine.

Table 11.3.3-11b
Economic Costs of Alternative Snowmobile Standards—Net Present Value 2002 through 2030[1]
(millions of 2001$, using 7 percent discount rate)

Scenario	Engineering Costs	Economic Costs (Surplus Losses)	Fuel Efficiency Cost Savings	Economic Gains or Costs[2]
Alternative 1	$106.6	$105.7	$86.8	($18.9)
Alternative 2	$235.7	$231.1	$327.2	$96.1
Final Program	$305.7	$296.9	$459.7	$162.8
Alternative 3	$531.5	$470.0	$487.4	$17.4
Alternative 4	$775.7	$713.1	$727.8	$14.7
Alternative 5[3]	$941.1	$847.6	$727.8	($119.8)

1. Assumes the final program Phase 1 standards as the first phase in each alternative
2. Economic costs or net economic costs shown in parenthesis.
3. Same standards as Alternative 4, but assumes a 25% increase in the cost of a 4-stroke engine.

11.3.3.6 Discussion

Alternative 1 (Phase 1 standards only) would require relatively minimal additional use of advanced technologies beyond what we project as a baseline. These advanced technologies (direct injection two-stroke, and four-stroke technologies) have been shown to be both feasible and capable of emissions reductions well below those required of the Phase 1 standards. Thus, we do not believe that this alternative would meet the basic criteria of the Clean Air Act which requires us to set standards based on the greatest degree of emissions reductions achievable.

Alternative 2 (Phase 2 HC standards with Phase 1 CO standards) would require roughly half of new snowmobiles to have advanced technology beginning with the 2010 model year, with the emphasis on direct injection two-stroke technology. The remaining snowmobiles would have a combination of engine modifications, recalibration and electronic fuel injection. We believe that a higher level of advanced technology than 50 percent penetration is certainly feasible beyond 2010 and therefore do not believe that in the absence of more stringent Phase 3 standards this alternative would meet the basic criteria of the Clean Air Act which requires us to set standards based on the greatest degree of emissions reductions achievable.

Alternative 3 (more stringent Phase 2 HC standards than final program in conjunction with Phase 1 CO standards) would require more advanced technology. We modeled 60 percent of the snowmobiles produced would be powered by four-stroke engines in 2010 and an additional ten percent would utilize direct injection two-stroke technology. The remainder would require some other technologies such as recalibrations and electronic fuel injection. We believe that these alternative standards strike a reasonable balance for allowing four stroke engines to be a primary Phase 2 technology, and have adopted these standards as an alternative to our primary Phase 2 standards on an engine family by engine family basis. Further discussion of our reasons for offering these standards as a Phase 2 option can be found in the preamble to the final rule.

Alternative 4 would require advanced technologies on all snowmobiles, beginning in 2010. We modeled 90 percent requiring four-stroke engines and the remaining ten percent requiring direct injection two-stroke technology. As discussed in detail in the preamble, given the number of snowmobile models and engine model offerings for each snowmobile model, and the fact that snowmobiles have not previously been regulated or used these advanced technologies in large numbers, we do not believe that it is feasible to apply and optimize advanced technology to every snowmobile by the 2010 model year. Thus we are not confident that this option is would be feasible in the time frame provided. We will, however, monitor the development and application of advanced technology and will in the future consider the adoption of snowmobile standards that would require advanced technology on every snowmobile.

Alternative 5 is simply a sensitivity analysis to look at how the cost of four-stroke engines might impact the consideration of Phase 2 standards which are based largely on four-stroke technology. This alternative has the same standards as Alternative 4, but with 25 percent higher costs for four-stroke engines.

11.4 Recreational Vehicle Permeation Emission Standards

While developing the fuel tank and hose permeation standards, we analyzed alternative approaches both more and less stringent than the final standards. These alternative approaches are discussed below.

11.4.1 Fuel Tanks

The final permeation standard for fuel tanks is 1.5 g/m^2/day when tested at 23°C on a test fuel with 90 percent gasoline and 10 percent ethanol. This standard represents approximately an 85 percent reduction from baseline HDPE fuel tanks. We considered an alternative standard equivalent to about a 60 percent reduction from baseline. This could be met by fuel tanks molded out of nylon. We also considered requiring metal fuel tanks which would essentially eliminate permeation emissions from fuel tanks.

11.4.1.1 60 Percent Reduction (Nylon Fuel Tanks)

One manufacturer commented that we should relax the fuel tank standard to a 55-60 percent reduction so that other technologies could be used. Specifically, they point to injection-molded nylon. Therefore, for this analysis, we consider the costs and emissions reductions associated with molding the fuel tank out of nylon.

As discussed in Chapter 5, nylon costs about $2.00 per pound while HDPE costs about $0.50 per pound. Depending on the shape of the fuel tank and the wall thickness, recreational vehicle fuel tanks weigh about 1-1.3 pounds per gallon. Including a 29% markup for overhead and profit, the increased cost for using nylon fuel tanks would be about $21 for snowmobiles (11 gallons), $10 for ATVs (4 gallons), and $8 for off-highway motorcycles (3 gallons). This is actually 5-10 times higher than our projected costs for using sulfonation to meet the final standard which represents about an 85 percent reduction.

Based on the data presented in Chapter 4, the use of nylon could achieve more than a 95 percent reduction in permeation compared to HDPE when gasoline is used. However, if a 10 percent ethanol blend is considered, then the reduction is only 40-60 percent depending on the nylon composition. On a 15 percent methanol blend, the permeation rate through nylon can actually be several times higher than through HDPE.

About one third of the gasoline sold in the U.S. today is blended with ethanol or some other oxygenate. In addition, the trend in the U.S. is towards using more renewable fuel and ethanol may be the leading choice. Therefore, it is important that the permeation control strategy used for recreational vehicles be effective on ethanol fuel blends. For this analysis, we consider a 10 percent ethanol blend when calculating emissions reductions.

Table 11.4-1 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-3). Table 11.4-2 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-1
Projected Fuel Tank Permeation Emissions from Recreational Vehicles for the Alternative Approach of a 60 Percent Reduction [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline control reduction	3,389 3,389 0	4,181 4,181 0	5,032 4,106 92	6,456 2,737 3,719	7,061 2,824 4,236
ATVs	baseline control reduction	3,985 3,985 0	6,751 6,751 0	9,275 8,072 1,202	11,109 5,455 5,654	11,231 4,539 6,692
OHMCs	baseline control reduction	882 882 0	1,303 1,303 0	1,710 1,492 218	2,061 1,239 821	2,248 1,315 933
Total	baseline control reduction	8,255 8,255 0	12,234 12,234 0	16,016 13,671 2,345	19,626 9,431 10,194	20,539 8,678 11,862

Table 11.4-2
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of a 60 Percent Reduction from Fuel Tanks

	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	$21	$3	0.0084	$2,541	$2,178
ATVs	$10	$2	0.0047	$2,065	$1,702
OHMC	$8	$1	0.0027	$2,819	$2,456

Constructing fuel tanks out of nylon would be significantly more expensive than constructing them out of HDPE and applying a barrier treatment such as sulfonation to control permeation. Therefore, we believe that most manufacturers would choose the lower cost option of applying a barrier treatment even if we were to set a standard based on a 60 percent reduction. In addition, we believe that they would target the maximum effectiveness of the barrier treatment. Designing for a 60 percent reduction would not have meaningful cost savings over designing for a 95 percent reduction. As a result, while this option could result in less emission control than the standard, we do not believe that it would lower costs for manufacturers.

11.4.1.2 Metal Fuel Tanks

One commenter pointed out that essentially a 100 percent reduction in fuel tank permeation emissions could be achieved by replacing plastic fuel tanks with metal fuel tanks. However, they stated that a performance standard approaching this amount of emission reduction would be appropriate because it would allow industry flexibility on how to meet the standard. For this scenario we consider the use of metal fuel tanks in recreational vehicles.

Today, most if not all recreational vehicles use plastic fuel tanks. According to manufacturers plastic fuel tanks are desirable because they weigh less than metal fuel tanks, are more durable, can be formed into more complex shapes, are non-corrosive, and cost less. In recreational vehicle applications, weight is an issue because the vehicles must be light enough to be manipulated by the rider. However, more importantly, durability is an issue because of the rough use of these vehicles and because many of the fuel tanks are exposed. For example, if a dirt bike were to fall over, a metal tank could be dented on a rock which would damage the integrity of the fuel tank. A plastic tank, however, would likely be undamaged. In addition metal fuel tanks have seams due to the manufacturing process which are weak point and could result in leaking. Fuel tanks on recreational vehicles, are designed to maximize the fuel stored in a limited space. Current plastic fuel tank designs are molded with contours that match the vehicle chassis. Manufacturers have stated that these complex shapes cannot be stamped into metal parts and that using metal tanks could cause them to need to redesign the fuel tank geometry and could require modifications to the chassis in order to maintain the same fuel capacity.

For the purposes of this analysis we use a cost increase of 30 percent for metal tanks versus plastic fuel tanks. This is based on pricing seen for marine applications which use metal fuel tanks in some cases. Because metal fuel tanks are not used in recreational vehicle applications, direct costs cannot be used. This cost does not include research and design costs that would be required for developing metal tanks or costs of modifying production practices. Dealer prices for plastic fuel tanks, of the size used in recreational vehicles, range from 3 to 9 dollars per gallon of capacity.[1] Using an average cost of 6 dollars per gallon and a typical dealer markup, we get a cost of about 2 dollars per gallon for plastic fuel tanks. This cost estimate for plastic fuel tanks was confirmed in conversations with recreational vehicle manufacturers. Based on this analysis and a markup of 29%, we estimate a cost increase of about $9 for snowmobiles, $3 for ATVs, and $2 for non-competition off-highway motorcycles.

Table 11.4-3 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-3). Table 11.4-4 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-3
Projected Fuel Tank Permeation Emissions from Recreational Vehicles for the Alternative Approach of a 100 Percent Reduction [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline	3,389	4,181	5,032	6,456	7,061
	control	3,389	4,181	3,489	258	0
	reduction	0	0	1,542	6,198	7,061
ATVs	baseline	3,985	6,751	9,275	11,109	11,231
	control	3,985	6,751	7,271	1,685	78
	reduction	0	0	2,004	9,424	11,153
OHMCs	baseline	882	1,303	1,710	2,061	2,248
	control	882	1,303	1,347	692	692
	reduction	0	0	363	1,369	1,556
Total	baseline	8,255	12,234	16,016	19,626	20,539
	control	8,255	12,234	12,107	2,635	770
	reduction	0	0	3,909	16,991	19,769

Table 11.4-4
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of a 100 Percent Reduction

	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	$9	$5	0.0140	$668	$305
ATVs	$3	$3	0.0078	$435	$72
OHMC	$2	$2	0.0046	$509	$146

Although this approach appears to be cost effective, we did not chose to set standards that would require manufacturers to use metal fuel tanks. We believe that there may be safety concerns with metal fuel tanks on recreational vehicles because of the rough use and likelihood of damage to the fuel tanks. Because some applications may be able to use metal fuel tanks, we will accept a metal tank for design-based certification to our standard. In addition, we believe that the final tank permeation standard can achieve nearly the same level of reduction as metal tanks while providing manufacturers very important flexibility in their design and manufacturing.

11.4.2 Hoses

The hose standard is 15 $g/m^2/day$ when tested at 23°C on a test fuel with 90 percent gasoline and 10 percent ethanol (E10). For hoses we considered basing the standard on testing with an alcohol-free test fuel. We also considered a standard that would require the use of fuel tubing, such as used in automotive applications, which is fairly rigid in comparison to fuel hoses because tubing is generally constructed out of fluorothermoplastics while hoses are primarily constructed out of rubber.

11.4.2.1 Alcohol-Free Test Fuel

Manufacturers commented that we should specify ASTM Fuel C (50% toluene, 50% iso-octane) for the hose permeation testing, stating that this is the fuel used for measuring permeation under the SAE J30 recommended practice for R9 hose. Under SAE J30, R9 hose must meet a permeation rate of 15 g/m^2/day when tested at 23°C. Manufacturers noted that fuels with ethanol-gasolines blends would have a higher permeation rate than if they were tested on gasoline. Therefore, R9 hose would not necessarily meet the hose permeation standards. As noted in Chapter 4, barrier materials typically used in R9 hose today may have permeation rates 3 to 5 times higher on a 10 percent ethanol blend than on straight gasoline. In this section, we analyze the alternative of basing our hose permeation standard on testing using an alcohol-free test fuel.

For the purposes of our benefits analysis, as described in Chapter 6, we estimated that a hose designed to meet 15 g/m^2/day on E10 fuel would permeate at half of that rate when tested on gasoline. This estimate considers the entire hose construction and not just the effect of alcohol on the barrier materials. To model this alternative, we doubled the estimated permeation rates for hoses meeting the permeation standards. Based on costs of hose available today, R9 hose would cost about $0.75/ft which represents a $0.50/ft increase from R7 hose used in most applications today. For the same reasons as discussed in Chapter 5, we are conservatively adding a cost of hose clamps ($0.20 each). As with the analysis in Chapter 5, we include a 29 percent markup in costs for profit and overhead.

Table 11.4.1-5 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-4). Table 11.4-6 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-5
Projected Fuel Hose Permeation Emissions from Recreational Vehicles for the Alternative Approach of Using an Alcohol-Free Test Fuel [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline	4,471	5,516	6,638	8,517	9,315
	control	4,471	5,516	4,659	564	254
	reduction	0	0	1,979	8,074	9,061
ATVs	baseline	4,243	7,189	9,876	11,829	11,959
	control	4,243	7,189	7,800	2,068	407
	reduction	0	0	2,076	9,761	11,552
OHMCs	baseline	1,878	2,774	3,642	4,389	4,787
	control	1,878	2,774	2,890	1,553	1,565
	reduction	0	0	751	2,836	3,222
Total	baseline	10,592	15,478	20,156	24,735	26,061
	control	10,592	15,478	15,349	4,184	2,225
	reduction	0	0	4,806	20,550	23,835

Table 11.4-6
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of Using an Alcohol-Free Test Fuel [short tons]

	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	$4	$7	0.0179	$212	($151)
ATVs	$1	$3	0.0081	$144	($219)
OHMC	$2	$3	0.0095	$157	($206)

We also received comment that we should use the most permeable fuel blend on the market for testing the permeation rates through hoses. As discussed above, we believe that the use of ethanol-blended gasoline is too significant today to ignore and could increase in the future. For this reason, we believe that it is appropriate to base the standards on testing using E10 fuel. We do not believe it is necessary to relax the standards to allow R9 hose to be able to pass on E10 fuel. Several materials are available today that could be used as a low permeation barrier in rubber hoses that are resistant to permeation on alcohol fuel blends. In fact, SAE J30 specifies R11 and R12 hose which are low permeability hoses tested on 15 percent methanol blend. Chapter 4 presents data on low permeation hoses developed for automotive applications that easily meet the final hose permeation standards that we believe could be used on recreational applications. Finally, the incremental cost is small ($0.10/ft) between hose that would meet 15 g/m^2/day on straight gasoline versus gasoline with a 10 percent ethanol blend.

11.4.2.2 Automotive Plastic Fuel Tubing

In developing emission standards for nonroad vehicles, the Clean Air Act requires us to first consider standards for comparable on-highway applications. In automotive applications, manufacturers generally use very low permeation plastic fuel tubing to meet our evaporative emission requirements. Recommended practice specified by SAE J2260 defines a Category 1 fuel line which must meet a permeation requirement of 25 g/m^2/day at 60°C on a test fuel with 85 percent gasoline and 15 percent methanol (M15). This is roughly equivalent to meeting a limit of 2 g/m^2/day at 23°C. In addition, based on the data in Chapter 4, permeation rates for most materials used in hoses tend to be at least twice as high for M15 than E10 fuel. This plastic tubing is generally made of fluoropolymers such as ETFE or PVDF.

Manufacturers commented that fuel hose standards based on automotive fuel lines such as specified in SAE J2260[2] as Category 1 would be inappropriate for recreational vehicles. Although this technology can achieve more than an order of magnitude lower permeation than barrier hoses, it is relatively inflexible and may need to be molded in specific shapes for each recreational vehicle design. Manufacturers have commented that they would need flexible hose to fit their many designs, resist vibration, and to simplify the hose connections and fittings.

Plastic fuel tubing would likely cost less than multilayer barrier fuel hoses, but we estimate that it would cost about $0.50 per foot more than the rubber hoses currently used on recreational vehicles. This additional cost includes a markup to form the tubing to the tight bends that would be required for recreational applications. Although the fluoroplastics are more expensive than the materials used in hoses on a per pound basis, plastic automotive tubing is constructed with thin walls (approximately 1 mm on average). An additional cost associated with automotive fuel tubing would be for more sophisticated connectors for the plastic tubing. On recreational vehicles using rubber fuel hose, the hose is generally just pushed on to connectors formed into the fuel tank and carburetor. In some cases, these are push on fittings without the use of a clamp. In automotive applications, quick connects are generally used which cost about $0.50 each.[3] For ATVs and OHMCs, we include the costs of two quick connects for each vehicle. Snowmobiles can require 4 to 8 quick connects depending on the fuel pump configuration, number of carburetors, and if a fuel return line is included. We include the cost of six quick connects in this analysis.

Table 11.4-7 presents the projected national emission reductions for this approach. These figures can be compared to the anticipated reductions presented in Chapter 6 for the final standards (Table 6.2.6-4). Table 11.4-8 presents the cost per ton of permeation emissions reduced per fuel tank, using a 7 percent discount rate and a 29 percent markup for overhead and profit, with and without fuel savings. These figures can be compared to the cost per ton presented in Chapter 7 (Table 7.1.5-1).

Table 11.4-7
Projected Fuel Hose Permeation Emissions from Recreational Vehicles for the Alternative Approach of Basing the Standard on Automotive Fuel Tubing [short tons]

Vehicle	Scenario	2000	2005	2010	2020	2030
Snow-mobiles	baseline	4,471	5,516	6,638	8,517	9,315
	control	4,471	5,516	4,605	348	8
	reduction	0	0	2,033	8,169	9,306
ATVs	baseline	4,243	7,189	9,876	11,829	11,959
	control	4,243	7,189	7,744	1,804	93
	reduction	0	0	2,132	10,026	11,865
OHMCs	baseline	1,878	2,774	3,642	4,389	4,787
	control	1,878	2,774	2,870	1,476	1,478
	reduction	0	0	772	2,913	3,310
Total	baseline	10,592	15,478	20,156	24,735	26,061
	control	10,592	15,478	15,219	3,627	1,579
	reduction	0	0	4,936	21,107	24,481

Table 11.4-8
Estimated Cost Per Ton of HC Reduced (7 percent discount rate) for the Alternative Approach of Basing the Standard on Automotive Fuel Tubing

	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	$6	$7	0.0184	$333	($30)
ATVs	$2	$3	0.0083	$233	($130)
OHMC	$2	$4	0.0097	$232	($131)

Although this approach appears to be cost effective, we did not choose to set standards that would require manufacturers to automotive type fuel tubing. We are concerned that the tubing is too rigid for the tight installation spaces and radii in recreational vehicle applications. Hoses on these vehicles today often have tight bends and are subject to high amounts of shock and vibration The above analysis does not include costs of adding additional length that may be required for molding in spirals or other bends for vibration resistance. Because some applications may be able to automotive fuel tubing, we will accept fuel lines conforming to SAE J2260 Category 1 for design-based certification to our standard. In addition, we believe that the final hose permeation standard can achieve nearly the same level of reduction as metal tanks while providing manufacturers flexibility in their design.

11.5 Incremental Cost Per Ton Analysis

The above discussion analyzes several options for the different engine categories. For completeness, we have also examined the cost per ton associated with the incremental steps in standards changes. The table below provides a summary of the incremental cost per ton for the differences in the alternatives analyzed above. Details of the alternative are provided above for each program.

Table 11.5-1: Incremental Cost Per Ton Estimates

Change in Standards	Average Cost		Lifetime Reductions per Vehicle (NPV tons) [a]		Discounted per Vehicle Cost Per Ton without Fuel Savings ($/ton) [a]		Discounted Per Vehicle Cost Per Ton with Fuel Savings ($/ton) [a]	
Off-highway Motorcycles (change in g/km HC+NOX standard)	w/o fuel savings	w/fuel saving	HC+NOx		HC+NOx		HC+NOx	
Baseline –> 4.0 g/km [b]	$210	$122	0.50		$420		$210	
Baseline –> 2.0 g/km	$158	$105	0.38		$410		$280	
2.0 g/km –> 1.0 g/km	$70	$70	0.02		$3,590		$3,590	
ATVs (change in g/km HC+NOX standard)	w/o fuel savings	w/fuel saving	HC+NOx		HC+NOx		HC+NOx	
Baseline –> 2.0 g/km	$73	$50	0.20		$370		$250	
2.0 –> 1.5 g/km	$11	$11	0.01		$1,010		$1,010	
1.5 –> 1.0 g/km	$48	$48	0.01		$4,740		$4,740	
Snowmobiles (HC/CO percent reduction)	w/o fuel savings	w/fuel saving	HC	CO	HC	CO	HC	CO
Baseline –> 30/30	$80	$13	0.40	1.02	$90	$40	$20	$10
30/30 –> 50/30	$131	($155)	0.10	0.16	$1,370	n/a	($1,610)	n/a
50/30 –> 50/50	$89	($102)	n/a	0.25	n/a	$330	n/a	($430)
50/30 –> 70/30	$287	$97	0.19	n/a	$1,540	n/a	$520	n/a
70/30 –> 85/50	$234	($50)	0.14	0.15	$820	$780	$180	($170)
Large SI	w/o fuel savings	w/fuel saving	HC+NOx		HC+NOx		HC+NOx	
Baseline –> Phase 1	$611	($3,370)	3.07		$240		($1,150)	
Phase 1 –> Phase 2	$55	$55	0.80		$80		$80	

a. Calculated using a discount rate of 7 percent.

b. The 4.0 g/km alternative requires manufacturers to certify competition off-highway motorcycles whereas the other alternative does not.

Chapter 11 References

1. www.marinepart.com/fuetmold, A copy of this has been placed in the Docket A-2000-01, Document IV-A-87.

2. SAE Recommended Practice J2260, “Nonmetallic Fuel System Tubing with One or More Layers,”1996, Docket A-2000-01, Document IV-A-18.

3. Denbow, R., Browning, L., Coleman, D., “Report Submitted for WA 2-9, Evaluation of the Costs and Capabilities of Vehicle Evaporative Emission Control Technologies,” ICF, ARCADIS Geraghty & Miller, March 22, 1999, Docket A-2000-01, Document No. IV-B-05.