Chapter 7: Analysis of Aggregate Costs

This chapter develops the uniform annualized cost per class and the average cost per equipment per class for this rulemaking. This chapter also assesses the cost-effectiveness, in terms of dollars per ton of total emission reductions. This analysis relies on cost information from Chapter 4 and 5 and emissions information from the small engine model[29] presented in Chapter 6. Lastly, this chapter discusses possible economic effects of the regulation and compares the cost effectiveness of the new provisions with the cost-effectiveness of other HC+NOx control strategies from previous EPA rulemakings.

7.1 Aggregate Cost Analysis

The analysis examines total annual costs of the proposed standards for all applicable engines[30] from 2001-2026. The complete year-by-year stream of costs over time that are summarized in this section can be found in Appendix E. The uniform annualized cost per class and average cost per equipment per class are calculated. Costs of variable hardware, production, research and development, and compliance programs are used and annualized where

[29] The nonroad small engine emission model accounts for factors including various equipment types, consumer or professional usage, lifetime of the equipment, scrappage, etc., see Chapter 6.

[30] The analysis covers all engines sold in the United States except those sold in California which are covered by rulemakings established by CARB.

appropriate. Cost savings due to reduced fuel consumption are also addressed, including the valuation of the reduced fuel consumption to the consumer. Total costs to society are presented as the aggregate costs to consumers with and without fuel savings.

This analysis is based on cost estimates for variable and fixed costs from the 1996 ICF and EF&EE cost study. The 1996 cost estimates are adjusted by a 4% inflation rate per year to the years included in this analysis (2001-2026). The costs for the compliance program were based on costs in 1997 and are also adjusted accordingly.

This analysis also accounts for estimates of the increased profits to economic entities in the various levels of industry, including the engine manufacturer, equipment manufacturer, and mass merchandiser. As rationalized in Appendix E, full cost pass through and profitability on increased costs are assumed. Table 7-1 summarizes the assumed profitability factors, sometimes referred to as retail price equivalent factors, which were applied to specific costs in this analysis, to estimate the price increase to the consumer.

Table 7-01
Profitability Factors
(Retail Price Equivalent Factors)

Level	Factor
Engine Manufacturer	0.16
Equipment Manufacturer	0.05
Mass Merchandiser	0.05

These factors were applied to the specific variable engine and equipment manufacturer costs identified in this chapter. For example, EPA has estimated

some variable hardware costs and production costs specific to engines and specific to equipment. From the consumer's point of view, the equipment specific costs were marked up the cost 10% and the engine specific costs were marked up 28%.

7.1.1. Uniform Annualized Costs

A uniform annualized cost is an expression of the equal annual payments that would be equivalent to a given cash flow schedule for a known interest rate. This expression of an annualized cost was chosen due to the variety of the programs that makeup this Phase 2 regulation. The methodology used for calculating the uniform annualized costs is as follows.

The EPA Phase 1 certification database was utilized to determine the number of engines, and related number of models, that would likely be improved during the course of the phase-in (see Tables E-01 to E-03). The costs per engine (variable and fixed costs) for emission improvements were estimated from the ICF cost study, as shown in Chapter 4. The variable costs per engine are then multiplied by the number of engines (for Classes III-V it was percentage phase-in times the production[31] in that year) in that year to incorporate that technology or set of technologies. The fixed costs are amortized for five years for engine manufacturers and ten years for equipment manufacturers starting in the phase-in years in which they are calculated to be recovered. Fixed costs are recovered through 2014 as shown in Table E-04.

[31] The future sales growth estimates are based on the assumptions utilized in the nonroad small engine emission model (SEEM) for the main types of equipment. The equipment are noted to be either handheld or nonhandheld based on the major engine type used in that category. The production values for the handheld and nonhandheld categorized equipment are added together for each year from 2001 to 2026. Growth factors for each year are determined by dividing the production for that year to the previous year. These factors are then utilized with the 1998 sales projections as the base and the resultant sales estimates for future years are developed. The resultant values for production of handheld and nonhandheld equipment are then further split into classes and engine technology types (such as SV and OHV) by the proportions in the 1998 database.

In order to determine the uniform annualized costs, the annual costs were discounted to the first year the Phase 2 standards are implemented, 2001 for nonhandheld engines and 2002 for handheld engines, at a rate of seven percent (the consumption rate of interest). The uniform annualized cost was obtained by summing the discounted costs over the appropriate time period and dividing by the appropriate present worth factor (at an interest rate of 7% over the corresponding number of years). The sections below address each cost category separately. Section 7.3. contains the full 20 year analysis of total cost of the proposed standards.

7.1.1.1. Variable Costs -- Table 7-02 contains the uniform annualized variable costs per class with consumer markup (see Table E-08 for costs per year on which this table is based). The results are calculated to first year of implementation which is 2001 for Classes I and II and 2002 for Classes III-V.

Table 7-02
UNIFORM ANNUALIZED VARIABLE COST PER CLASS
WITH CONSUMER MARKUP
($Thousands)

CLASS	ENGINE	EQUIPMENT	TOTAL
I	$6,251	$0	$6,251
II	$24,821	$308	$25,129
III	$0	$0	$0
IV	$0	$0	$0
V	$0	$0	$0

7.1.1.2. Capital Costs -- Engine improvements, and thereby capital expenditures, are phased-in over time for Classes II-V and incurred in

one year for Class I. The phase-in and number of models for all Classes were determined in Chapter 4. Capital costs are estimated to be recovered over 5 years for engine manufacturers and 10 years for equipment manufacturers, at a 7 percent interest rate. Costs incurred prior to the initial year of the Phase 2 rulemaking were moved to the first year of the rulemaking (i.e., the first year in which costs are recovered) using a 7 percent interest rate.

Potential capital cost increases include costs for development and application of engine designs with reduced emissions and costs for test facilities. EPA has not accounted for any costs due to construction of test facilities due to the fact that manufacturers already have facilities due to the EPA Phase 1 and CARB's Tier I, and likely Tier II, rulemakings. There is also a significant amount of lead time and a phase-in of most engine class standards which will allow the most efficient use of current facilities.

EPA has estimated the uniform annualized fixed costs as shown in Table 7-03. The results are calculated to first year of implementation which is 2001 for Classes I and II and 2002 for Classes III-V. Appendix E contains the tables on which this table is based.

Table 7-03
UNIFORM ANNUALIZED FIXED COST PER CLASS
($Thousands)

CLASS	ENGINE	EQUIPMENT	TOTAL
I	$938	$0	$938
II	$3,974	$2,402	$6,376
III	$689	$0	$689
IV	$20,363	$85	$20,448
V	$3,848	$7	$3,848

7.1.1.3. Compliance Costs -- This rulemaking accounts for those costs that are above and beyond those for the Phase 1 program. These costs are the compliance program costs presented in Chapter 5. Compliance costs include costs for bench-field adjustment factor program, certification for nonhandheld SV engines[32], in-use bench or field aging and production line testing (PLT). All costs are considered variable costs for this analysis. This is assumed because compliance costs are a small part of this overall rulemaking and the major programs are industry wide which result in a lower cost per engine manufacturer than if they had done the programs independently. Appendix E and Chapter 5 contain details on the program costs assumed for the compliance programs. The estimates for the administrative burden for these programs are estimated in the supporting statements for the Information Collection Requests submitted to OMB. These supporting statements contain

[32] Certification for all engines in this class are not included in this cost analysis due to the fact that this cost analysis considers costs beyond those that are included in the Phase 1 program. SV engines have extra certification requirements beyond those in Phase 1.

estimates of the testing, record keeping, and reporting burden on industry due to the final regulations.

Table 7-04 contains the uniform annualized compliance costs for all classes. The results are calculated to first year of implementation which is 2001 for Classes I and II and 2002 for Classes III-V.

Table 7-04
UNIFORM ANNUALIZED COMPLIANCE PROGRAMS
($Thousands)

CLASS	COST
I	$652
II	$2,741
III	$30
IV	$1,963
V	$361

The total uniform annualized costs for this rulemaking are presented in Table 7-05. The results are calculated to first year of implementation which is 2001 for Classes I and II and 2002 for Classes III-V. The total value is calculated with all costs to 2001.

Table 7-05
TOTAL UNIFORM ANNUALIZED COSTS
INCLUDING CONSUMER MARKUPS
($Thousands)

Class	Cost
I	$7,841
II	$34,245
III	$719
IV	$22,410
V	$4,215
TOTAL	$67,270*

* All classes calculated to 2001

7.1.1.4. Fuel Savings -- As explained in Chapter 4, the technological changes necessary to bring these engines into compliance with the emission standards will cause a decrease in fuel consumption of approximately 15% for a nonhandheld Class II SV engine, 17% for a Class III or IV handheld engine and 6% for a Class V handheld engine. The tons/year savings per class (see Appendix E) are converted to gallons/year and then multiplied by $0.765/gallon to determine the fuel savings[33]. Table 7-06 contains the uniform annualized fuel savings for all equipment types in each class which have been discounted 3% to the year 2001 or 2002 for nonhandheld and handheld engines respectively. The total value is for all classes discounted to the year 2001. Table E-07 contains the yearly fuel savings information on which this

[33] The value of gasoline is $0.765 per gallon. This is based on the average refinery price to enduser in 1995 from the Energy Information Administration.

analysis is based.

Table 7-06
UNIFORM ANNUALIZED FUEL SAVINGS
and COMPARISON TO UNIFORM ANNUALIZED COST
($Thousands)

CLASS	UNIFORM ANNUALIZED FUEL SAVINGS	UNIFORM ANNUALIZED COST	RESULTANT COSTS (SAVINGS)
I	$0	$7,841	$7,841
II	$107,914	$34,245	($73,669)
III	$470	$719	$249
IV	$11,448	$22,410	$10,962
V	$1,135	$4,215	$3,080
TOTAL	$120,258*	$67,270*	($52,988)

* All Classes calculated to 2001

7.1.2. Average Cost Per Equipment

The average cost per equipment changes over time due to the recovering of capital costs and the increased production over which costs can be spread. Therefore this analysis calculates a range of cost that is based on the uniform annualized cost. Since the production of these engines is assumed to increase over the years of this analysis, this section presents a range of cost per equipment estimates. The uniform annualized cost is divided by the production in the first full implementation year (2005) and the last year (2026) accounted for in this analysis. Results are shown in Table 7-07. An average of this range is also presented.

Table 7-07
AVERAGE COST PER EQUIPMENT PER ENGINE CLASS
BASED ON UNIFORM ANNUALIZED COST

	2005	2026	Average
I	$0.90	$0.83	$0.87
II	$10.99	$10.10	$10.54
III	$0.83	$0.64	$0.74
IV	$2.17	$1.67	$1.92
V	$18.32	$14.10	$16.21

7.1.2.1. Fuel Savings -- The resultant fuel savings per engine per class is calculated in the same manner as the cost per equipment. The uniform annualized fuel savings is divided by the production in the years 2005 and 2026 to yield a range of costs for this analysis. The resultant cost per engine is then calculated by subtracting the fuel savings per engine from the total cost per equipment. Both results are listed in Table 7-08 below.

Table 7-08
FUEL SAVINGS AND
RESULTANT COST PER ENGINE
Based on Uniform Annualized Analysis

Class	Average Cost Per Engine	Average Savings Per Engine	Average Resultant Cost Per Engine
I	$0.87	$0.00	$0.87
II	$10.54	$33.20	($22.66)
III	$0.74	$0.45	$0.29
IV	$1.92	$0.99	$0.93
V	$16.21	$4.12	$12.09

NOTE: This table shows the costs and savings spread across all engines within each engine class and not only those engines which will incorporate technology changes.

Table 7-08 shows that EPA assumes no fuel savings from Class I engines. This is due to the assumption that the changes to these engines will not affect fuel usage. For Class II engines, EPA assumes that there will be significant savings as SV engines are phased-out and replaced with more fuel efficient OHV engines. The high savings per engine in this class are also influenced by the fact that the engines in this class are utilized for longer hours compared to the other classes. The differences seen in the handheld classes (Classes III-V) are due to influential factors contained in the nonroad small engine emission model from which they were calculated. Such factors include application, useful life, scrappage curve, and engine power. For example, Class V engines are higher in power and thereby the fuel savings are more notable, even though on a per engine basis, the assumption was only a 6% savings from Phase 1 to Phase 2 engines which is less than the 17% decrease assumed for Class III and

IV. Class IV engines are assumed to see a higher savings per engine, likely also due to the higher power in this class than from Class III engines. Another reason for the discrepancy in Class V engines is that the model uses an estimate of sales for all Class V engine families and the cost estimates were based on those families certified to the EPA Phase 1 standard as of September 1, 1997. It is expected that this value will be reduced as more engine families are certified to the Phase 1 standard. Likewise the cost per engine may likely decrease as larger engine families are certified.

The overall increase in price per engine class is minimal compared to the selling price of the equipment in which small SI engines are used. For Class I engines, the major selling equipment type is the walk behind lawnmower. Some popular lawnmowers sell for $150. The increased cost estimate of $0.87 is less than 1% of this price. Class II equipment are much higher in price and the common equipment types include garden tractors and lawn tractors. These equipment sell for approximately $1000 to the consumer. On average, consumers are expected to see an overall fuel savings in the use of this equipment. Handheld equipment in Classes III-IV include the trimmer which can be found in the marketplace for $100.00. An increase of $1.00 per equipment is only 1% of this price. Class V equipment includes chainsaws which sell for approximately $200.00. An increase of $12.00 is 6% of this price.

7.2 Cost Effectiveness

The following section describes the cost effectiveness of the proposed HC+NOx standards for the various Classes of small SI engines. As discussed

in Chapter 4, the estimated cost of complying with the provisions varies depending on the model year under consideration. The following section presents the total cost effectiveness over all of the model years after the standards take effect. These cost effectiveness numbers are calculated by taking the net present value of the total costs per year (including amortized capital and variable costs) over the 26 year time line, discounted by 7%[34], and dividing it by the net present value of the emission benefits discounted by 3%. Table 7-09 presents the resulting cost effectiveness results.

Table 7-09

Cost Effectiveness of Phase 2 Rulemaking

	Cost Effectiveness ($/ton)
Without Fuel Savings	$390
With Fuel Savings	-$700

In an effort to evaluate the cost-effectiveness of the new standards, EPA has summarized the cost effectiveness results for several other recent EPA mobile source rulemakings. Table 7-10 summarizes the cost effectiveness results from the Small SI Engine Phase 1 rulemaking, the SI Marine OB/PWC Engine rulemaking(2) and the recently proposed standards for nonroad compression ignition (CI) engines (3).

[34] The NPV analysis uses the nominal discount rate of 7% for costs based on the fact that a 4% inflation rate is included for costs of this rulemaking. Fuel savings were discounted a 3% due to the fact that an inflation rate was not used in the fuel savings calculation.

Table 7-10
Cost Effectiveness of Other Like Rulemakings
With Fuel Savings

Rulemaking	Cost Effectiveness	Pollutants
Small SI Engine Phase 1	$217	HC+NOx
Marine	$1000	HC
Nonroad CI Standards	$180-$400	HC+NOx

7.3. 20-Year Analysis

Table 7-11 contains the year by year fleet wide costs and emission benefits associated with the proposed small SI engine standards of the 20 year period from 2001-2020. Fuel savings are not included for they significantly dilute the costs to the manufacturers. An interest rate of 4% was included to compute the costs per year based on 1996 and 1997 cost estimates for technology and compliance program costs respectively. (The numbers presented in Table 7-11 are not discounted).

Table 7-11
Costs and Emission Benefits of the Proposed Small SI Engine Standards
Fuel Savings Not Included

Calendar Year	Fleetwide Costs	Fleetwide Reductions (short tons) HC+NOx
2001	$30,303,001	7,161
2002	$42,276,239	19,833
2003	$58,035,173	35,840
2004	$113,365,495	55,380
2005	$127,081,704	77,530
2006	$133,003,771	93,994
2007	$108,225,857	105,241
2008	$98,818,904	112,731
2009	$40,346,826	117,931
2010	$37,105,261	121,915
2011	$38,326,627	125,121
2012	$38,918,557	127,812
2013	$40,296,949	130,157
2014	$39,266,478	132,284
2015	$37,568,287	134,280
2016	$38,358,252	136,198
2017	$40,460,456	138,068
2018	$41,348,504	139,908
2019	$43,631,544	141,729
2020	$44,640,116	143,536

Table 7-12 contains the discounted year by year fleet wide costs and emission benefits associated with the proposed small SI engine standards for the 20 year period from 2001 to 2020. The year by year results were discounted to 2001 and a discount rate of seven percent was assumed for the analysis.

Table 7-12
Discounted Costs and Emission Benefits of the Proposed Small SI Engine Standards
Fuel Savings Not Included

Calendar Year	Fleetwide Costs	Fleetwide Reductions (short tons) HC+NOx
2001	$30,303,001	7,161
2002	$39,510,504	18,535
2003	$50,690,168	31,304
2004	$92,540,013	45,207
2005	$96,950,023	59,147
2006	$94,829,851	67,017
2007	$72,115,458	70,127
2008	$61,539,447	70,203
2009	$23,482,220	68,637
2010	$20,182,803	66,314
2011	$19,483,314	63,605
2012	$18,489,926	60,723
2013	$17,892,327	57,791
2014	$16,294,192	54,893
2015	$14,569,630	52,076
2016	$13,902,796	49,364
2017	$13,705,356	46,768
2018	$13,089,878	44,291
2019	$12,908,999	41,932
2020	$12,343,364	39,689

Summing the discounted annual costs and discounted emission reductions over the twenty year period yields a 20-year fleet wide cost of $735 million and 20-year emission reductions of 1.01 million tons of HC+NOx. The

resulting 20 year annualized fleet wide costs and emission reductions are $69 million per year and 96,000 tons per year of HC+NOx. The spreadsheets prepared for this analysis are contained in Appendix E. The reader is directed to the spreadsheets for a complete version of the analysis.

Chapter 7 References

1. ICF and Engine, Fuel and Emissions Engineering, Incorporated; "Cost Study For Phase Two Small Engine Emission Regulations", Draft Final Report, October 25, 1996, EPA Air Docket A-93-29, Docket Item #II-A-04.

2. "Air Pollution Control; Gasoline Spark-Ignition Marine engines; New Nonroad Compression-Ignition and Spark-Ignition Engines, Exemptions; Rule", US EPA, Federal Register, vol 61, No. 194, Friday October 4, 1996, 40 CFR parts 89, 90 and 91, pg 52100

3. "Control of Emissions of Air Pollution from Nonroad Diesel Engines; Proposed Rule", US EPA, Federal Register, vol. 62, No 85, Wednesday, September 24, 1997, page 50152.