COMPARISONS OF ESTIMATED AND ACTUAL POLLUTION CONTROL COST FOR SELECTED INDUSTRIES

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SUMMARY AND OVERVIEW

Introduction

Federal environmental regulations have experienced significant growth in the 1970's. The costs of these regulations are an issue of intense interest and controversy to both industry and the government. The Environmental Protection Agency (EPA) has routinely developed estimates of pollution control costs and their economic impact for every major regulation. It often has been suggested that EPA compare its cost forecasts with actual expenditure data. The purpose of this report is to compare estimates of pollution abatement costs prepared by EPA, by EPA contractors, by industry, and by independent groups with reported expenditures.[1] Pollution abatement capital cost estimates for specific regulations were compared with reported capital expenditures for the following six industries.

- Steam Electric Utilities -- BPT effluent guidelines
- Electric Utility Flue Gas Desulfurization Systems -- Scrubbers
- Pulp and Paper -- BPT effluent guidelines
- Petroleum Refining -- BPT effluent guidelines
- Iron and Steel -- BPT effluent guidelines
- Automobiles -- Light duty vehicle air pollution controls.

For each industry and regulation several estimates are provided including an EPA and industry estimate developed at

[1] Expenditure forecasts designated as an "industry estimate" refer to studies prepared or sponsored by individual firms, industry trade associations, or by a loose collection of firms such as the Utility Water Act Group.

about the time that the regulations were promulgated. In several cases a number of other estimates are given from other sources such as the National Academy of Science, the National Commission on Water Quality, the EPA Cost of Clean Air and Water report to Congress, and so forth. Actual expenditure data are taken from a variety of sources including surveys from the Census Bureau, the Department of Commerce/Bureau of Economic Analysis, McGraw-Hill, the Bureau of Labor Statistics, and industry trade associations. In cases where three or more sources of actual expenditure data are available, usually one source was significantly different than the others. For example, the McGraw-Hill survey reported substantially higher figures in the iron and steel industry and pulp and paper industry than the other sources. In the petroleum refining industry, the BEA survey was considerably higher than the other surveys.

Methodology

When comparing EPA and industry cost forecasts with actual expenditures a number of adjustments were made. First, forecasted expenditure studies usually project only incremental costs due to federal regulations and do not account for: (1) construction work in progress -- these costs are included in the year when the plant is placed in service; (2) pollution control costs voluntarily incurred, for example, for economic reasons; (3) costs associated with state and local requirements. As these costs are included in the survey of actual expenditures they had to be added back into the EPA and industry forecasts. A second major adjustment was to scale forecasted expenditures by the actual compliance rate.[1] Finally, for each industry all figures were

[1] In the case of automobile pollution controls and electric utility scrubbers, these adjustments were not made because actual expenditures were reported on a unit basis (e.g., dollars per car or dollars per kilowatt).

converted to constant dollars using the appropriate pollution control deflator.

Summary of Results

Table 1 compares EPA and industry capital cost estimates with actual expenditures for five industries. (Please refer to the appropriate industry section for a discussion of the expenditure forecasts, actual expenditure data, forecasts by independent groups, key assumptions, and so forth.) This table illustrates several trends. First, for four of the five industries examined the EPA estimates are lower than the industry estimates. However, for refineries it is only the most recent EPA Cost of Clean Air and Water report which is lower than the industry estimate. Second, both EPA and industry forecasts tend to overestimate compliance costs more often than they underestimate these costs. For example, EPA forecasts (excluding the Cost of Clean forecasts) range from 26 percent below to 156 percent above reported expenditures, while industry forecasts range from 25 percent below to 247 percent above reported expenditures. If this trend to overestimate compliance costs were further substantiated by looking at a larger sample of industries and including operating costs, it could have implications for EPA decision-making, particularly for decisions requiring a balancing of benefits and costs.

When comparing expenditure forecasts to reported expenditures, EPA forecasts are closer to the actual figures for the iron and steel industry and for electric utilities; industry estimates are closer for the pulp and paper industry and for electric utility scrubbers, while the forecasted expenditures for the refining industry are about the same.

Table 2 compares estimates of automotive pollution control price increases with actual sticker price increases. These data

indicate that EPA estimates are closer to the actual price increases than the industry estimates. The manufacturers' estimates indicate a large degree of variance; however, since individual manufacturer estimates were not given in this data source, it is impossible to determine if they overestimate control costs without knowing if the higher estimates are from the larger manufacturers.

Finally, in comparing EPA and industry national aggregate cost forecasts, differences in these forecasts result from a combination of different assumptions regarding unit control costs, the amount of capacity affected, the industrial growth rate, and the assumed rate of implementation of the program. A more in-depth review of the cost studies is needed to identify the key assumptions responsible for the disparate EPA and industry estimates. However, for the steam electric BPT guidelines some information is available. The industry unit cost estimates for non-nuclear plants complying with the chemical guidelines were three times higher than EPA's estimates. Additionally, industry projected higher capacity growth rates. Taken together, these two assumptions result in an industry estimate 70 percent higher than EPA's estimate. Even assuming EPA's growth rate, the industry's higher unit cost factors result in an estimated cost of compliance 53 percent higher than EPA estimates.

TABLE 1

RATIO OF EXPENDITURE
FORECASTS TO ACTUAL EXPENDITURES[1,2]

Expenditure Forecasts	1974-1977	1975-1977	1972-1977
Utilities (BPT Guidelines)			
EPA	.89-.91		
Industry	1.36-1.40		
Electric Utility Scrubbers[3]			
EPA	.74		
Industry	.91		
Pulp and Paper (BPT Guidelines)			
EPA	1.27-1.49		
Cost of Clean[4]			1.14
Industry			.75
Refineries (BPT Guidelines)			
EPA	1.87-2.5		
Cost of Clean[4]			1.82-1.84
Industry	1.91-2.62		
Iron and Steel (BPT Guidelines)			
EPA		1.32-1.79	
Cost of Clean[4]			.55- .85
Industry		2.56-3.47	

[1]These ratios are forecasted expenditures divided by actual expenditures.

[2]The range of values reflects comparisons with several expenditure surveys.

[3]These are composite figures representing comparisons including scrubbers installed on new units and scrubbers retrofitted on existing units on a 21 plant sample. (See Section II for more details.)

[4]The Cost of Clean Air and Water, Report to Congress, August 1979.

TABLE 2

RATIO OF ESTIMATED TO
ACTUAL STICKER PRICE INCREASES

	ACTUAL PRICE INCREASES[1]	
	BLS Data	Manufacturers' Data
Model Year 1973-1974		
EPA Estimate	1.32-1.45	1.54-1.69
Industry Estimate	.72-1.74	.85-2.03
Model Year 1975-1976		
EPA Estimate	.93-1.02	.95-1.05
Industry Estimate	.51-2.31	.53-2.37
Model Year 1980		
EPA Estimate	.82	

[1] These price increases are that portion of the reported price increases which are attributable to addition or improvement of pollution control equipment.

I. EFFLUENT GUIDELINES FOR STEAM ELECTRIC POWER PLANTS

Introduction

The effluent guidelines for steam electric powerplants promulgated on October 8, 1974 included three categories: thermal guidelines, chemical guidelines, and the entrainment regulations. The thermal guidelines require: (1) all new units to install closed cycle cooling when placed in service, and (2) all units greater than 500 MW and placed in service between 1 January 1970 and 1 January 1974 to retrofit from open cycle to closed cycle cooling by 1 July 1981. The chemical guidelines limit pH levels, suspended solids, oil and grease, metals, chlorine and certain other pollutants in waste streams. Initial limitations went into effect in 1977 and more stringent requirements are to go in effect in 1983. The entrainment regulations require the location, design and construction of cooling water intake structures to reflect the best available technology for minimizing environmental impact. Since capital expenditures due to the entrainment regulations are not expected until after 1980, they are not included in this analysis.

Methodology and Data Sources

In this analysis EPA and industry estimates were compared with two expenditure surveys. The EPA estimates were prepared by Temple, Barker & Sloane, Inc.;[1] the National Economic Research Associates[2] prepared estimates for industry (Utility Water Act

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[1] Economic Analysis of Effluent Guidelines: Steam Electric Powerplants, December 1974.

[2] Utility Water Act Group Economic Analysis submitted as comments to the proposed effluent guidelines for steam electric powerplants, June 1974.

Group), and actual expenditure data were given in the McGraw-Hill survey[1] and the Bureau of Economic Analysis survey.[2] The EPA and industry studies used a different accounting procedure to tabulate capital expenditures than the survey data. To make these sources compatible certain adjustments were made to the EPA and industry expenditure forecasts. These studies projected the incremental costs due to federal regulation and they did not account for: (1) costs voluntarily incurred, for example, because of economic reasons; (2) costs of construction work in progress -- these costs were included in the year when the unit was expected to be placed in service; (3) costs associated with state and local requirements. As the McGraw-Hill and BEA data report total pollution abatement expenditures, the types of expenditures listed above had to be added back into the EPA and industry forecasts.

Another major adjustment was to scale the expenditure estimates by the 68% compliance rate reported by the EPA Office of Enforcement. Further, the industry study forecasted capital expenditures only for the 1974-1983 period. Estimates for the 1974-1977 period were developed by assuming the distribution of costs in time would be the same as in the EPA study. This assumption is reasonable when similar industrial growth rates and capacity installation rates are used. Finally, all figures were adjusted to 1974 dollars using the Census Bureau's new plant and equipment price deflator for water pollution abatement equipment.

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[1] Historical Pollution Control Expenditures and Related Data, McGraw-Hill, November 1979.

[2] "Capital Expenditures by Business for Pollution Abatement", Survey of Current Business, July 1975, June 1977, June 1979.

Cost Comparisons

Table 3 compares EPA and industry (UWAG) capital cost factors on a dollars/kilowatt basis. EPA's estimates are only slightly lower than industry's estimates for the thermal guidelines. However, for the chemical guidelines, EPA's non-nuclear estimate is less than one third of the corresponding industry estimate while the nuclear estimates are about the same. Table 4 compares EPA and industry capital expenditure estimates for water pollution abatement equipment with actual expenditures reported for the years 1974-1977. The EPA estimates are slightly lower than actual expenditures while the industry estimates are considerably higher (see chart below).

RATIO OF ESTIMATED CAPITAL EXPENDITURES TO REPORTED CAPITAL EXPENDITURES

Estimated Expenditures	Actual Expenditures	
	McGraw-Hill	DOC/BEA
EPA	.91	.89
UWAG	1.40	1.36

Differences in EPA and UWAG projected capital expenditures for water pollution control equipment result from differences in two key assumptions in their financial models. First, UWAG and EPA used different capital cost factors as shown in Table 3. Second, UWAG does not agree with the future industry growth rates assumed in the EPA study. The EPA assumptions were developed by the National Power Survey's Technical Advisory Committee on Finance. UWAG projected higher industry growth rates than EPA approaching historical rates observed in the past. (A later EPA study in May 1976 revised downward the total capital expenditure estimates given in this study because even lower growth rates were predicted which means fewer new plants would be built than

had previously been expected.) The UWAG estimates in Table 4 reflect just the higher capital cost factors and not the higher growth rate in electrical generation capacity. Using the UWAG assumed growth rate and capital cost factors, the expenditures are projected to be $2.9 billion for the 1974-1977 period. These figures are 52-56% higher than actual expenditures.

TABLE 3

COMPARISON OF EPA AND
UTILITY WATER ACT GROUP CAPITAL COST FACTORS
(Expressed in 1972 Dollars/Kilowatt)

	EPA ESTIMATE	UWAG ESTIMATE
Thermal Guidelines		
For Retrofitted Units		
Non-Nuclear	$20.43	$22.44
Nuclear	$24.58	$27.01
For New Units		
Non-Nuclear	$ 4.89	$ 6.40
Nuclear	$ 3.84	$ 4.27
Chemical Guidelines[1]		
Capacity prior to 1974		
Non-Nuclear	$ 1.70	$ 5.78
Nuclear	$ 0.58	$ 0.53
Capacity 1974-1978		
Non-Nuclear	$ 1.29	$ 4.58
Nuclear	$ 0.58	$ 0.53

[1] The estimates are the projected costs to meet the 1977 BPT chemical guidelines.

TABLE 4

CAPITAL EXPENDITURES FOR 1977 BPT GUIDELINES
(Billions of 1974 Dollars)

	1974-77	1974-83
EXPENDITURE FORECASTS		
EPA - DECEMBER 1974	1.7[1]	6.6
(Economic Analysis of Effluent Guidelines Steam Electric Powerplants)		
UWAG[2] - JUNE 1974	2.6[1]	8.9
(UWAG Economic Analysis was prepared by National Economic Research Associates, Inc.)		
ACTUAL FORECASTS		
McGRAW-HILL - NOVEMBER 1979		
(Historical Pollution Control Expenditures and Related Data)	1.86[3]	--
DOC - BUREAU OF ECONOMIC ANALYSIS		
(Capital Expenditures by Business for Pollution Abatement)	1.91[3]	--

[1] The 1974-1977 estimates have been adjusted from that reported in their respective studies to include construction work in progress, pollution abatement expenditures incurred voluntarily (e.g., for economic reasons), and a compliance rate of 68%.

[2] This expenditure estimate assumes only the higher UWAG capital cost factors shown in the previous table, and not the higher growth rate in electrical capacity.

[3] This figure has been adjusted to 1974 dollars using the Census Bureaus' new plant and equipment price deflator for water pollution abatement equipment.

II. ELECTRIC UTILITY FLUE GAS DESULFURIZATION SYSTEMS (SCRUBBERS)

Introduction

The 1970 Clean Air Act amendments required EPA to develop National Ambient Air Quality Standards. The states were required to implement measures to assure the standards would be attained. As fossil fuel electric powerplants are among the largest sources of air pollution, much effort was directed at controlling these sources. Rather than focus on the total cost of this program we have chosen to examine the costs of scrubbing sulfur dioxide emissions -- one of the most controversial elements of EPA's program.

Methodology and Data Sources

In the analysis below, all cost estimates and reported expenditures are compared on a unit (dollars/kilowatt) basis rather than on an aggregate basis. Actual costs for the period 1970-1978 are reported in a recent EPA study[1] which summarized capital expenditures from 21 plants that have installed flue gas desulfurization (FGD) on 10,981 MW of generation capacity. The expenditures cover just the sulfur dioxide portion of the emission control system and were adjusted to 1977 dollars. The EPA cost estimates were taken from a report prepared for EPA by Temple, Barker & Sloane, Inc., in May 1976.[2] Industry estimates were

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[1] Utility FGD Costs: Reported and Actual Costs for Operating FGD Systems. PEDCO, 1978.

[2] Economic and Financial Impacts of Air and Water Pollution Controls on the Electric Utility Industry. Temple, Barker & Sloane, Inc., 1976.

prepared by the National Economic Research Associates.[1] The National Public Hearings on Powerplant Compliance with Sulfur Oxide Air Pollution Regulations was another source of cost estimates.[2] All cost estimates and expenditures were adjusted to 1977 dollars using the Chemical Engineering Index.

Cost Comparisons

Table 5 compares EPA and industry cost estimates with reported capital expenditures for sulfur dioxide (SO_2) scrubbers. The reported capital expenditures are averages from the 21 plant sample. The observed spectrum of control costs ranged from \$67-\$118/KW for new units and from \$56-\$233/KW for retrofitting existing units. EPA estimates are lower than industry estimates and both are lower than average reported expenditures. The chart below summarizes the differences between scrubbing cost estimates and the reported average expenditures. The industry's estimate of the retrofit cost agrees quite closely with the actual reported expenditures, while EPA's estimate was 77 percent of actual reported expenditures. Industry underestimated the costs of scrubbers on new plants by 16 percent, while EPA underestimated the costs by 30 percent.

RATIO OF SCRUBBING COST ESTIMATES TO REPORTED EXPENDITURES

	New Unit Cost	Retrofit Cost
EPA	.70	.77
National Public Hearings	--	.69-.89
Industry	.84	.96

[1] The Cost of Reducing SO_2 Emissions from Electric Utility Plants. NERA, June 1975.

[2] Report of the Hearing Panel, National Public Hearings on Powerplant Compliance with Sulfur Oxide Air Pollution Regulations, October 18, 1973 to November 2, 1973.

Since the costs are being compared on a unit basis, one would expect the costs to be in fairly close agreement. However, the EPA costs are substantially lower. Using the EPA cost factors and the PEDCO 21 plant sample, EPA would have estimated the capital expenditures to be 26 percent (or $234 million) less than the actual figure. Using the industry cost factors they would have estimated capital expenditures to be 9 percent (or $81 million) less than the actual figure. Total capital expenditures for the 21 plants were $1,152 million during the 1970-1978 period.

TABLE 5

COST OF SO_2 SCRUBBERS[1] ($/KW)
(1977 Dollars)

	NEW UNIT COST	RETROFIT COST
EXPENDITURE FORECASTS		
EPA - MAY 1976 (Economic and Financial Impacts of Air & Water Pollution Controls on the Electric Utility Industry)	62[2]	79[2]
National Public Hearings on Power Plant Compliance with Sulfur Oxide Air Pollution Regulations (Oct. 1973)	--	71-92
Industry - JUNE 1975 (The Cost of Reducing SO_2 Emissions from Electric Utility Plants)	74	99
ACTUAL EXPENDITURES		
EPA/PEDCO - SEPTEMBER 1978 (Utility FGD Costs: Reported and Adjusted Costs for Operating FGD Systems)	88	103

[1] All costs have been adjusted to 1977 dollars using the Chemical Engineering Index to conform with the PEDCO reported data.

[2] Using the inflation rate suggested in the EPA report, the estimated scrubber costs are $65 for a new plant and $82 to retrofit an existing plant.

III. PULP AND PAPER INDUSTRY

Introduction

Effluent guidelines for the pulp and paper industry were developed for each of 17 subindustrial categories. The guidelines required limitations on pH levels, biological oxygen demand, suspended solids, and zinc in wastewater streams. The major industrial subcategories examined in this analysis are bleached kraft, groundwood, sulfite, soda, de-inked and non-integrated paper segments of the pulp, paper and paperboard industry.

The estimated costs of compliance with BPT regulations, as calculated by both the EPA and the pulp and paper industry, are presented below. These estimates are then compared with the actual water pollution abatement expenditures made by the industry. All of the cost figures in this section are adjusted to 1975 dollars, using the Census Bureau's new plant and equipment price deflator for water pollution abatement equipment.

Methodology and Data Sources

While there are a number of studies which calculate the cost of compliance with BPT in the pulp and paper industry, only three of these are used in this analysis. The reason for this exclusion of data lies in the fact that most of the studies concerning this industry report the estimated expenditures in dollars per ton by subindustry (e.g., bleached kraft; market pulp; papergrade sulfite; soda, de-inked; etc.). In order to compare these cost figures with actual expenditures data, a conversion from dollars per ton to total dollars would have to be made. To make such a conversion, an estimate for the number of treated tons of production in each of these subindustries

is needed. Unfortunately, this tonnage figure is not readily available. Therefore, those estimates which are stated only on a dollar per ton basis have been excluded.

The two EPA studies[1] and the one industry study[2] chosen for analysis estimate the industry-wide capital expenditures necessary to meet BPT guidelines on a total dollar basis. These estimates have been adjusted to reflect an 83 percent compliance rate for the industry.[3]

There are four data sources containing information on water pollution abatement capital expenditures in the pulp and paper industry. These include the Census, BEA, and McGraw-Hill publications[4] in addition to a National Council of the Paper Industry for Air and Stream Improvement[5] (NCASI) publication on environmental expenditures in the pulp and paper industry.

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[1] Economic Analysis of Proposed and Interim Final Effluent Guidelines for the Bleached Kraft, Groundwood, Sulfite, Soda, De-inked and Non-Integrated Paper Sectors of the Pulp and Paper Industry, 1/76, Arthur D. Little, and The Cost of Clean Air and Water Report to Congress, August 1979.

[2] Potential National Economic Impact of Federal Water Effluent Standards and Goals for the U.S. Paper Industry, Arthur D. Little, 12/73, for the American Paper Institute.

[3] Aggregated from compliance data obtained from the EPA Enforcement Office on paper products, paper mills, and pulp mills.

[4] McGraw-Hill Publications Co., Dept. of Economics, Historical Pollution Control Expenditures and Related Data.

[5] NCASI, A Survey of Pulp and Paper Industry Environmental Protection Expenditures - 1978, Special Report No. 79-03, 9/79.

Cost Comparisons

Tables 6 and 7 depict the estimated capital costs of compliance with BPT relative to the reported actual capital expenditures.

The industry estimate by ADL, approximately 25 percent below the actual 1972-1977 capital expenditures as they are reported by NCASI and McGraw-Hill, is the only estimate of the three which is lower than the reported actual expenditures. It should be noted, however, that the actual data are only available for the entire "Paper and Allied Products" industry, and therefore may overstate slightly the actual expenditures for the pulp and paper segment of the industry.

Both of the EPA estimates are slightly higher than the actual expenditures. The forecasted costs reported in the January 1976 study by ADL averaged 38.1 percent higher than the actual expenditures. The estimate taken from the 1979 Cost of Clean Air and Water report averaged 14 percent higher than the actual expenditures.

TABLE 6

THE COST OF COMPLIANCE WITH THE BPT REGULATIONS:
PULP AND PAPER INDUSTRY[1]
(millions of 1975 dollars)

	1974-77	1972-77
Actual Expenditures[2]	$ 876.0-$1028.6[3]	$1411.2-$1411.9[4]
EPA Estimates		
ADL - Jan. 1976	1304.8	--
Cost of Clean - Aug. 1979	--	1608.2
Industry Estimates		
ADL - Dec. 1973	--	1064.1

1. All of the cost estimates below have been adjusted for a compliance rate of 83 percent.

2. These are actual capital expenditures for water pollution abatement by the entire paper and allied products industry.

3. The lower and upper bounds reflect the actual water pollution expenditure data from BEA and McGraw-Hill respectively. The intermediate values are: Census: $972.2 million and NCASI: $916.3 million.

4. The upper and lower bounds of this range reflect NCASI and McGraw-Hill expenditures data, respectively.

TABLE 7

RATIO OF ESTIMATED COST OF COMPLIANCE
TO ACTUAL WATER POLLUTION ABATEMENT EXPENDITURES[1]

	1974-1977	1972-1977
EPA ESTIMATES		
EPA/ADL	1.27-1.49	--
Cost of Clean	--	1.14
INDUSTRY ESTIMATE		
API/ADL	--	.75

[1]The range of values reflect comparisons with different expenditure surveys.

IV. PETROLEUM REFINING

Introduction

The BPT effluent guidelines promulgated in October 1974 for the petroleum refining industry require the control of wastewater pollutants for five refinery categories: topping, cracking, petrochemical, lube, and integrated. The effluent guidelines require limitations on pH levels, biological and chemical oxygen demand, suspended solids, oil and grease, phenolic compounds, ammonia, sulfide, and chromium in wastewater streams.

The estimates of the cost of compliance with EPA BPT guidelines and the actual water pollution abatement expenditures made in the petroleum refining industry are presented below. The cost estimates include EPA estimates,[1] industry estimates,[2] and an estimate taken from a study contracted by the National Commission on Water Quality.[3] All of the cost data in this section have been converted to 1974 dollars using the Census Bureau's new plant and equipment price deflator for water pollution abatement equipment.

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[1] From Economic Impact of EPA's Regulations on the Petroleum Refinery Industry, 4/76, and The Cost of Clean Air and Water Report to Congress, August 1979.

[2] From The Economic Impact of Environmental Regulations on the Petroleum Industry, Phase II Study, Battelle Columbus Laboratories, 6/11/76

[3] From Water Pollution Control Act of 1972. Economic Impacts Pilot Studies, Five Industries, The Conference Board, 6/75.

Methodology and Data Sources

The capital expenditure estimates in the petroleum refining industry are comparable without adjustment. Each estimate includes anticipated expenditures for both existing and new refineries. However, in order to make these estimated capital expenditures consistent with the actual expenditures reported for the petroleum refining industry, all of the estimates were adjusted to reflect an industry compliance level with the BPT guidelines of 83 percent.[1]

There are four sources of actual water pollution abatement expenditures for the petroleum refining industry. These data sources are published by the Bureau of the Census, the Department of Commerce/Bureau of Economic Analysis, McGraw-Hill,[2] and the American Petroleum Institute[3] (API). Unfortunately, only the Census data are broken out for the petroleum refining sector of the petroleum industry.

The API data, while not disaggregated to the level of the individual sectors of the petroleum industry, allocate water pollution abatement capital expenditures to four industrial activities: exploration and production; transportation; marketing; and manufacturing. For the purposes of this study, the manufacturing segment has been chosen as the best approximation for

[1]This level of compliance was obtained from the EPA Enforcement Office.

[2]McGraw-Hill Publications Co., Dept. of Economics, Historical Pollution Control Expenditures and Related Data.

[3]API, Environmental Expenditures of the United States Petroleum Industry 1969-1978. Only the data for the manufacturing portion of the industry were employed.

the petroleum refining industry, and it is this portion of the API data which is reported herein.

In order to analyze the remaining two sources of actual data at the petroleum refinery level, the ratio of the manufacturing segment expenditures to the total industry expenditures, as reported by API, has been applied to the capital expenditures reported in the BEA and the McGraw-Hill publications.

The Census, API, and McGraw-Hill expenditures data are very similar, while the BEA shows slightly larger capital expenditures for water pollution abatement. These data are shown in Table 8.

Cost Comparisons

As is depicted in Tables 8 and 9, both of the EPA estimates and the industry estimate show substantially greater anticipated expenditures than those that actually occurred. The National Commission estimate is much closer to the reported actual expenditure data. This is largely due to the fact that the National Commission incorporated anticipated technological changes into its model in order to arrive at the minimum estimated cost of compliance with BPT.

A second comparison of EPA and industry estimates is shown in Table 10. This table presents a case study example involving the water pollution abatement expenditures at one petroleum refinery. This example depicts a different trend from that seen previously. Note that both the EPA and the industry estimates are lower than the actual cost of the pollution abatement project, with EPA's estimate 43.8 percent below the actual cost and industry's estimate 26.9 percent lower.

TABLE 8

THE COST OF COMPLIANCE WITH BPT REGULATIONS:
PETROLEUM REFINERY INDUSTRY[1]
(millions of 1974 dollars)

	1974-77	1972-77
Actual Expenditures[2,3]	$ 545.5-$ 747.8[4]	$ 786.8-791.6[5]
EPA Estimates		
Sobotka - April 1976	1397.5	-
Cost of Clean - Aug. 1979	-	1444.4
Industry Estimates		
API/Battelle - June 1976	1426.7	-
National Commission on Water Quality		
Conference Board - June 1975		707.3

1. All cost estimates have been adjusted for a compliance rate of 83 percent.

2. Only the API capital expenditures for the manufacturing sector of the petroleum industry are included.

3. The BEA and the McGraw-Hill surveys report data for the entire petroleum industry. In order to obtain an expenditures figure for only the petroleum refinery industry, the API ratio of petroleum manufacturing expenditures to total industry expanditures has been applied to the BEA and McGraw-Hill data.

4. The lower and upper bounds of the range depict the McGraw-Hill and the BEA figures respectively. The intermediate expenditure values are: Census - $585.8 million and API - $574.9 million.

5. The lower and upper bounds of the range depict the API and the McGraw-Hill figures respectively.

TABLE 9

RATIO OF ESTIMATED COST OF COMPLIANCE
TO ACTUAL WATER POLLUTION ABATEMENT EXPENDITURES[1]

	1974-77	1972-77
EPA Estimates		
Sobotka - April 1976	1.87-2.56	
Cost of Clean - August 1979	-	1.82-1.84
Industry Estimates		
API/Battelle - June 1976	1.91-2.62	
National Commission on Water Quality		
Conference Board - June 1975	-	.89- .90

[1]The range of values reflects comparisons with different expenditure surveys.

TABLE 10

CASE STUDY: A WATER POLLUTION ABATEMENT PROJECT

Expenditures by one refinery
(millions of 1972 dollars)

	EPA Cost Estimate	Industry Cost Estimates	Actual Cost
Expenditures	$3.6	$4.683	$6.404
Percent difference from actual	(43.8)	(26.9)	

Source: The Conference Board, Water Pollution Control Act of 1972 Economic Impacts Pilot Studies, Five Industries, 6/75.

V. IRON & STEEL INDUSTRY

Introduction

The BPT effluent guidelines for the integrated iron and steel industry establishes limitations for each individual manufacturing process (e.g., sintering, basic oxygen furnace, etc.). The guidelines require limitations on pH levels, suspended solids, oil and grease, heavy metals, and other pollutants in wastewater streams.

The estimates of the costs of compliance with the BPT regulations and the actual water pollution abatement expenditures in the iron and steel industry are reported below. The estimated costs of compliance which are shown in Table 11 consist of two EPA estimates, one industry estimate, and one estimate from the National Commission on Water Quality. All of the cost figures presented in this section have been converted to 1975 dollars using the Census Bureau's new plant and equipment price deflator for water pollution abatement equipment.

Methodology and Data Sources

In order to compare the cost estimates with actual expenditure data, all the estimates must be adjusted to a common, consistent basis. In the case of the iron and steel industry studies, a number of adjustments to the original estimates were necessary to achieve such consistency. The methodology used in this process is described below.

The first adjustment involved ensuring consistency between the EPA and the industry estimates. The industry estimate, taken from an Arthur D. Little, Inc. (ADL) study conducted for the American

Iron and Steel Institute[1] (AISI), had already been adjusted for comparative purposes in the EPA steel study by Temple, Barker & Sloane (TBS).[2] In an analysis of the capital expenditures necessary to meet BAT guidelines, TBS achieved comparability with the ADL estimates by applying a .9652 factor to the ADL cost figures. This same factor was applied to the ADL estimate used in this analysis for the capital expenditures needed to meet the BPT guidelines.

The second adjustment concerned accounting for Construction Work in Progress (CWIP) in the cost estimate. It was necessary to adjust the cost estimates for the inclusion of CWIP since the reported actual capital expenditures include this cost element. While the TBS study includes a CWIP figure, the ADL report does not. Since the TBS and ADL figures were already on a comparable basis, the TBS reported CWIP was added to the adjusted ADL estimate. This procedure yielded an industry estimate which was inclusive of CWIP. Finally, all of the cost estimates were weighted by a compliance factor of 54 percent.[3]

There are four sources which report capital expenditures for water pollution abatement in the iron and steel industry. These are: the Bureau of the Census Current Industrial Reports,[4] (Census), the Department of Commerce/Bureau of Economic Analysis[5]

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[1]ADL, Steel and the Environment: A Cost Impact Analysis, 5/75.

[2]TBS, Economic Analysis of Proposed and Interim Final Effluent Guidelines, Integrated Iron and Steel Industry, 3/76.

[3]This is the compliance rate for the Iron and Steel Industry as reported by the EPA's Enforcement Office.

[4]Pollution Abatement Cost and Expenditures, annual sin-e 1973.

[5]Articles on pollution abatement and control expenditures are published in the June and February issues of the Survey of Current Business.

(BEA), the American Iron and Steel Institute[1] (AISI), and McGraw-Hill.[2]

The iron and steel industry capital expenditures are reported separately in each of these sources except for the BEA publication. The related industries for which expenditures are reported by the BEA are "primary metals", "blast furnaces and steel products", and "non-ferrous metals". In order to capture the amount expended by steel and iron foundries, as well as that expended by "blast furnaces and steel products", the expenditures by the non-ferrous metals industry were removed from total "primary metals" expenditures. The resulting figures are the BEA capital expenditures included in this analysis.

The data from the four sources differ somewhat and the range of actual capital expenditures is depicted in Table 11. Each cost estimate is examined relative to the reported actual expenditures in Table 12.

Cost Comparisons

As is shown in Table 12, all of the earlier estimates of the cost of compliance with BPT were significantly higher than the actual expenditures reported by the four sources of actual pollution control costs. The AISI/ADL industry estimate is particularly high. This estimate of $1,613.5 million is 247% higher than the AISI actual water pollution abatement expenditure figure.

The best estimate of the cost of compliance with the BPT guidelines was made by EPA in the 1979 Cost of Clean Air and Water. This estimate of $593.7 million for the years 1972 1977 is 15.2% lower than the AISI actual expenditure figure.

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[1] AISI Statistical Highlights U.S. Iron and Steel Industry 1969-1978.

[2] McGraw-Hill Publications Co., Department of Economics, Historical Pollution Control Expenditures and Related Data.

TABLE 11

COSTS OF COMPLIANCE WITH BPT REGULATIONS:
THE IRON AND STEEL INDUSTRY[1]
(millions of 1975 dollars)

	1975-77	1973-77	1972-77
Actual Expenditures[2]	465.1-630.0[3]	624.3-952.6[4,5]	699.9-1070.6[5,6]
EPA Estimates			
TBS - March 1976	831.6[7]	-	-
Cost of Clean - Aug. 1979	-	-	593.7
Industry Estimates			
AISI/ADL - May 1975	1613.5	-	-
National Council on Water Quality Estimate, The Conference Board[8] - June 1975	-	1173.6	-

1. These costs reflect the capital expenditures only.

2. The BEA figure represents the pollution abatement expenditures by the primary metals industry less those expenditures made by the non-ferrous metals industry.

3. This range is bounded on the lower end by the AISI expenditures figure and by the McGraw-Hill cost figure in the upper end. The intermediate Census and BEA figures are $513.4 and $479.7 million respectively.

4. The lower bound of the range reflects the AISI cost figure and the upper bound reflects the McGraw-Hill cost figure. The intermediate Census and BEA figures are 714.8 and 645.0 respectively.

5. The Census data for 1973 are not broken out by air and water. To obtain only the capital expenditures for water pollution abatement, the 1973 total expenditure figure was adjusted using the 1974 ratio of water control expenditures.

6. The lower bound of the range is the AISI cost figure and the upper bound is the McGraw-Hill cost figure.

7. This is the cost estimate reported by TBS as the capital expenditure required to meet BPT. Since TBS did not feel that compliance with the BPT guidelines could be met in 1977, this estimate differs from the TBS estimate of expenditures for the years 1975-1977. The BPT estimate was chosen since it is more comparable to the other estimates studied.

8. The Conference Board, Water Pollution Control Act of 1972 Economic Impacts Pilot Studies, Five Industries, 1975.

TABLE 12

RATIO OF ESTIMATED COST OF COMPLIANCE TO ACTUAL WATER POLLUTION ABATEMENT EXPENDITURES[1]

	1975-1977	1973-1977	1972-1977
EPA Estimates			
TBS - March 1976	1.32-1.79	-	-
Cost of Clean - Aug. 1979	-	-	.55-.85
Industry Estimate			
AISI/ADL - May 1975	2.56-3.47	-	-
National Commission on Water Quality			
The Conference Board - June 1975	-	1.23-1.88	-

[1] The ranges of values reflect comparisons with different expenditure data surveys.

VI. AUTOMOBILES

Introduction

The 1970 Amendments to the Clean Air Act called for EPA to establish emission standards for 1975 and later model year light duty passenger cars to require a 90 percent reduction in hydrocarbon (HC) and carbon monoxide (CO) emissions from 1970 levels, and to proscribe standards for 1976 and later model years to require a 90 percent reduction in nitrogen oxide (NO_x) emissions from 1971 levels. A number of controversial suspension hearings, judicial reviews and legislative changes have altered the original emission standards and extended their compliance dates. Consequently, many of the earlier cost studies were for emission standards that were never placed in effect or were delayed several years from their original timetable.

Methodology and Data Sources

The methodology for this analysis was straightforward. It consisted of collecting the data and adjusting the sticker price increases to constant dollars. Estimates of sticker price increases are provided by EPA, the National Academy of Sciences, automobile manufacturers as reported in EPA automobile emission control status reports, and by the Council on Environmental Quality. Actual price increases are taken from two sources: the Bureau of Labor Statistics and manufacturers' reported actual price increases submitted in letters to Senators E.S. Muskie and P.V. Domenici.

Cost Comparisons

Table 13 compares actual and estimated sticker price increases due to emission controls. Table 14 lists the ratio of estimated price increases to actual price increases for model years 1973-1974, 1975-1976, and 1980. For the 1973-1974 standard the EPA and CEQ estimates appear to be the best, however, both estimates are substantially higher than reported price increases. For the 1975-1976 standard the EPA and NAS estimates appear to give the closest results to the reported figures. The manufacturers' estimates show a considerable amount of variance. This is not unexpected since there are significant differences in economies of scale between large and small manufacturer Individual manufacturer estimates were not indicated in these ranges. In comparing EPA estimates for the 1980 model year with the b.. data we find that EPA has underestimated the control costs by 18 percent. This is in contrast to the 1973-1974 standard where EPA overestimated the cost by 32-69 percent.

From analyzing the data in Table 13 and Table 14, it appears that the EPA estimates are closer to the actual price increases than the manufacturer estimates. The manufacturers' estimates have a large degree of variance and since individual manufacturer estimates are not given it is impossible to determine if they consistently overestimate control costs without knowing if the higher estimates are from the larger manufacturers.

As many of the early estimates were for standards that were never implemented, comparisons with actual data are not possible. However, Table 15 lists various estimates for meeting these standards. It should be noted that comparing the (.41/3.4/2.0)[1] standard with model year 1977, provides cost estimates

[1]The first number in the parentheses refers to the HC emission standard, the second figure refers to the CO emission standard, and the last number refers to the NO_x standard. All standards are given in units of grams per mile.

of applying control equipment to reduce HC and CO emissions from the 1977 level of 1.5 g/mi for HC and 15 g/mi for CO. Comparing the (.41/3.4/.4) standard with model year 1977 reflects the cost of the above reductions plus lowering NO_x emissions from 2.0 g/mi to .4 g/mi. In comparing the (.41/3.4/.4) standard with an unregulated vehicle all the estimates tend to group together except the EPA estimate which is low. For the other (.41/3.4/.4) standard there appears to be no clear-cut trend. For the (.41/3.4/2.0) standard the DOT/EPA/FEA estimates are significantly lower than the manufacturers' estimates.

TABLE 13

COMPARISONS OF ESTIMATED AND ACTUAL STICKER PRICE INCREASES DUE TO EMISSION CONTROLS
(1977 Dollars)

Emission Standards ($HC/CO/NO_x$)	Bureau of Labor Statistics Actual Price Increases[1,2]		Manufacturers Reported Actual Price Increases[3]		EPA Estimates[4]		NAS Estimates[6]		Manufacturer Estimates[7]		CEQ Estimates[9]	
	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative
MY 70-71 (4.1/34/--)	33	33	27	27	39.00		28		--	--	35	35
MY 72 (3.0/28/--)	8	41	19	41		39.00		28	--	--	2	37
MY 73-74 (3.0/28/3.1)	35	76	24	65	61.00	100-110[5]	93	121	55-132	55-132	61	98
MY 75-76 (1.5/15/3.1)	139	215	144	209	100-110	200-220	83	204	55-364	110-496	209	307
MY 77-79 (1.5/15/2.0)	35	250	--	--	15	215			0-182[8]			
MY 80 (.41/7.0/2.0)	99	349	--	--	70	285			--			
MY 81 (.41/3.4/1.0)	--	--	--	--	150	435			154-378[8] (over MY 75-76)			

[1] These figures are from the Bureau of Labor Statistics reports on price changes of new passenger cars. Price increases were adjusted to 1977 dollars.

[2] Incremental prices are the prices over the previous model year. Cumulative prices are the prices over pre-1970 cars.

[3] These prices are sales weighted averages of GM, Ford, and Chrysler average price increases due to emission controls as reported by Mr. E. M. Estes, President, General Motors, to Senator E. S. Muskie, May 19, 1975; Mr. L. A. Iocacca, President, Ford Motor Co., to Senator P.V. Domenici, May 13, 1975; and Mr. J. J. Ricardo, President, Chrysler Corp., to Senator P.V. Domenici, May 21, 1975.

[4] For the 1970-1974 model years the EPA figures reflect estimates in The Economics of Clean Air, Annual Report to Congress, March 1972 and the Cost of Clear Air and Water Report to Congress, August 1979. Other estimates are from the EPA Fact Sheet #1, 1978 and an EPA report entitled Automobile Emission Control - The Technical Status and Outlook as of December 1974.

[5] The upper bound cumulative cost reflect EPA estimates taken from the December 1974 status report. It did not give incremental costs for previous model years.

[6] The estimates for model years 1970-1972 were taken from the NAS 1972 report (Semiannual Report by the Committee on Motor Vehicle Emissions). The 1974 NAS report provided the estimates for the 1974 and 1975 model years.

[7] The manufacturing estimates are reported in the December 1974 EPA status report on automobile emission controls cited above and in a similar status report dated April 1976.

[8] The costs were only expressed as an increment over the prior model year in the April 1976 EPA Status Report.

[9] These estimates are from the Economic Impact of Pollution Control, March 1972.

TABLE 14

RATIO OF ESTIMATED TO ACTUAL STICKER PRICE INCREASES[1, 2]

Emission Standards ($HC/CO/NO_x$)	Actual Price Increases	
	BLS Data	Manufacturers' Data
MY 1973-1974 (3.0/28/3.1)		
EPA Estimate	1.32-1.45	1.54-1.69
NAS Estimate	1.59	1.86
Manufacturer Estimates	.72-1.74	.85-2.03
CEQ Estimate	1.29	1.51
MY 1975-1976 (1.5/15/3.1)		
EPA Estimate	.93-1.02	.95-1.05
NAS Estimate	.95	.97
Manufacturer Estimates	.51-2.31	.53-2.37
CEQ Estimate	1.42	1.47
MY 1980 (.41/7.0/2.0)		
EPA Estimate	.82	

[1] All comparisons are with cumulative estimates.

[2] The range of values reflects comparisons of the various estimates of sticker price increases with the actual reported increases.

TABLE 15

COMPARISON OF ESTIMATED STICKER PRICE INCREASES
DUE TO PROPOSED EMISSION STANDARDS
(1977 Dollars)

Emission Standard ($HC/CO/NO_x$)	Base Year[1]	EPA[2,3]	DOT/EPA/FEA[4]	CEQ[5]	NAS[6]	GM[7,8]	FORD[8]	Chrysler[8]	Industry Average
(.41/3.4/.4)	Uncontrolled	291-496		442	378-498	402-549	--	--	--
(.41/3.4/.4)	MY 77	--	250-340	--		165-375	316-401	127-287	204-368
(.41/3.4/2.0)	MY 77	110-165	35-125	--	--	149	165	237	184

[1] Costs are expressed as an increment above the base year.

[2] For the (.41/3.4/.4) standard the lower estimate was given in the March 1976 status report Automobile Emission Control - Current Status and Development Trends, the higher estimate was given in the December 1974 status report. The Economics of Clean Air Report to Congress, 1972 gives an intermediate estimate of $418.

[3] For the (.41/3.4/2.0) standard the values are reported in the hearings transcript for the Suspension of the 1977 Standards.

[4] An Analysis of Alternative Motor Vehicle Emission Standards, May 19, 1977, prepared by DOT/EPA/FEA for use in Congressional debates on the Clean Air Act Amendments of 1977.

[5] The Economic Impact of Pollution Control, March 1972.

[6] The lower value is from the 1972 Semiannual Report by the Committee on Motor Vehicle Emissions and the higher value is from the 1974 Committee report.

[7] The estimated range for the (.41/3.4/.4) standard is from the Application for Suspension of the 1975 Standards submitted to EPA on December 22, 1972.

[8] The auto company estimates are in the Suspension transcript or Applications for Suspension of the 1977 Standards.