COMPARISONS OF ESTIMATED AND ACTUAL POLLUTION CONTROL CAPITAL EXPENDITURES FOR SELECTED INDUSTRIES

Prepared for

Office of Planning & Evaluation
U.S. Environmental Protection Agency

Prepared by

Putnam, Hayes and Bartlett, Inc.

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COMPARISONS OF ESTIMATED AND ACTUAL POLLUTION CONTROL CAPITAL EXPENDITURES FOR SELECTED INDUSTRIES

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 are compared with reported capital expenditures for the following six industries.

- Steam Electric Utilities -- Water Pollution Control
- Electric Utility Flue Gas Desulfurization Systems -- Scrubbers
- Pulp and Paper -- Water Pollution Control
- Petroleum Refining -- Water Pollution Control
- Iron and Steel -- Water Pollution Control
- Automobiles -- Light Duty Vehicle Air Pollution Controls.

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

Methodology and Limitations of Analysis

For each industry and regulation several estimates are provided including an EPA and industry estimate developed at 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[1] report to Congress, and so forth. Actual expenditure data are taken from a variety of sources including surveys from the Department of Commerce, Bureau of the Census; the Department of Commerce, Bureau of Economic Analysis; McGraw-Hill Publications, Inc.; the Department of Labor, Bureau of Labor Statistics; and, industry trade associations.

In a study comparing cost forecasts with actual expenditures several limitations may arise. First, the accuracy of the survey data on actual capital expenditures is difficult to assess 'oecause the effort applied by industry personnel in completing the survey forms is unknown and can vary from one company to another. Since reported expenditures are the benchmark by which cost forecasts are measured, errors in this area could lead to misleading conclusions . 'Whenever possible a number of surveys of actual expenditures are reported.[2]

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[1]The Cost of Clean Air and Water report had an advantage over other cost forecasts in that it estimated expenditures from a retrospective point of view rather than projecting future expenditures.

[2]1n cases where three or more sources of actual expenditure data are available, usually one source was significantly different from t'ne 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, t'ne Bureau of Economic Analysis survey was considerably higher than the other surveys.

Another problem inherent in a study of this nature is that surveys of actual expenditures and cost forecasts may not measure or estimate the same quantity. The industry and EPA cost forecasts examined in this study usually estimated the incremental cost associated with federal regulation. The surveys on the other hand, report actual expenditures for total water or air pollution abatement. Therefore, when comparing EPA and industry cost forecasts with reported expenditures, pollution control costs associated with non-federal regulations had to 'oe added to the cost forecasts. Several other adjustments were also required. First, the cost forecasts sometimes used a different accounting procedure than the surveys of actual expenditures,. and this necessitated the addition of the cost of construction work in progress to the cost forecasts. Second, all figures. were converted to common dollars using in most cases the Bureau of the Census' new plant and equipment price deflator. Finally, when comparing the predicted expenditures with reported expenditures, the EPA and industry forecasts were scaled by the actual industry compliance rate.[1]

It should be kept in mind that this study only compares predicted capital expenditures with reported capital expenditures. Analysis of the operating and maintenance cost components should be conducted to verify and extend the analysis of capital expenditures.

[1]In the case of automobile pollution controls and electric utility scrubbers, the adjustment for industry compliance rate was not necessary because actual expenditures were reported on a unit basis (e.g., dollars per car or dollars per kilowatt).

Summary of Results

Table 1 compares EPA and industry capital cost estimates with actual expenditures for five industries. (Please refer to the industry sections of this report for a detailed discussion of the expenditure forecasts, actual expenditure data, key assumptions, and so forth.) The figures in Table L represent the ratio of forecasted expenditures to actual expenditures. For each industry, several forecasts (EPA, industry, and in some cases the Cost of Clean Air and Water forecast) are used and thus several ratios are calculated. In addition, a range of ratios is shown in cases where several surveys of actual expenditures were available.

Table 1 illustrates several facts. First, for four of the five industries examined the EPA estimates are lower than the industry estimates.[1] EPA forecasts have been closer to the actual figures for the iron and steel industry, the refining industry, and for electric utility water pollution control costs. Industry estimates have been closer to the actual figures for the pulp and paper industry and for eiectric utility scrubbers. Second, both EPA and industry forecasts tend to overestimate compliance costs more often than they underestimate t'nese costs. For example, EPA forecasts (excluding the Cost of Clean Air and Water forecasts) range from 26 percent beLow to 156 percent above reported expenditures, while industry forecasts range from 25 percent below to 162 percent above reported expenditures. If this apparent bias to overestimate compliance costs were further substantiated by looking at•

[1]However, for petroleum refineries and the iron and steel industry, it is only the most recent EPA Cost of Clean Air and Water report whit'n is lower than the industry estimate.

larger sample of industries and including operating and maintenance costs as well as capital costs, it could have implications for EPA decision-making, particularly for decisions requiring a balancing of benefits and costs.

Table 2 compares estimates of automotive price increases due to pollution control with actual sticker price increases. These data indicate that EPA estimates have been closer to the reported price increases than the industry estimates. The manufacturers' estimates show a large degree of variance. One would expect that the larger manufacturers would, because of economies of scale, be able to produce pollution control systems for their cars at a lower cost than smaller manufacturers. However, since individual manufacturer estimates were not available for these emission standards, it is impossible to determine if they overestimate or underestimate control costs without knowing which estimates are from the larger manufacturers.

In comparing EPA and industry cost forecasts, it is important to bear in mind that differences in these forecasts result from a variety of assumptions regarding unit control costs, the amount of capacity affected by regulation, 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.

TABLE 1

RATIO OF CAPITAL EXPENDITURE FORECASTS TO REPORTED CAPITAL EXPENDITURES[1,2]

Expenditure Forecasts	TIME PERIOD 1974-1977	1975-1977	1972-1977
Utilities (Water Pollution)			
EPA	.89-.91		
Industry	1.36-1.40		
Electric Utility Scrubbers			
EPA	.74		
Industry	.91		
Pulp and Paper (Water Pollution)			
EPA	1.27-1.49		
Cost of Clean[3]			1,14
Industry			.75
Refineries (Water Pollution)			
EPA	1.87-2.5		
Cost of Clean[3]			1.82-1.84
Industry	1.91-2.62		
Iron & Steel (Water Pollution)			
EPA		1.32-1.79	
Cost of Clean[3]			.55-.95
Industry	1.29-1.96[4]		

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

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

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

[4]These ratios are for the 1973-1977 time period.

TABLE 2

RATIO OF ESTIMATED TO REPORTED
ACTUAL STICKER PRICE INCREASES

PRICE INCREASE FORECASTS	SOURCE OF 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 guide-lines, and 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 L 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 t'he 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

[1] Economic Analysis of Effluent Guidelines: Steam Electric Powerplants, Temple, Barket & Sloane, Inc., December 1374.

Research Associates[1] prepared estimates for industry (Utility Water Act Group), and actual expenditure data were provided in the McGraw-Hill survey[2] and the Bureau of Economic Analysis survey.[3] 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: .(2) costs of construction work in progress -- these costs were included in the year when the unit was expected to be placed in service instead of as incurred: and, (3) costs associated wit'n state and local requirements. As the McGraw-Hill and Bureau of Economic Analysis data report total pollution abatement expenditures, these types of expenditures had to be added back into the EPA and industry forecasts.

A second 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 from this study by Putnam, Hayes & Bartlett, Inc. by assuming the distribution of costs in time would be the same as that assumed by the EPA study. This assumption is reasonable when similar industrial growth rates and capacity installation rates are used. The industry study assumed a different industrial growth rate than the EPA cost

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

[2] Historical pollution Control Expenditures and Related Data, McGraw-Hill, November 1979.

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

forecast. However, the EPA study included a comparison of the industry's capital cost forecasts with its own forecasts assuming similar industrial growth rates. The industry cost forecasts used herein are taken from the EPA study. Finally, all figures were adjusted to 1974 dollars using the Bureau of the Census' new plant and equipment price deflator for water pollution abatement equipment.

Cost Comparisons

Table 3 compares EPA and industry (u'WAG) capital expenditure estimates for water pollution abatement equipment with actual expenditures reported for t'ne years 1974-1977. The EPA estimates are slightly lower than actual expenditures while the industry estimates are considerably higher. The chart below provides the ratio of estimated expenditures to actual expenditures for t'ne various forecasts and actual expenditure surveys.

RATIO OF ESTIMATED CAPITAL EXPENDITURES TO REPORTED CAPITAL EXPENDITURES

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

Differences in EPA and UWAG projected capital expenditures result from differences in a key assumption in their analysis. UWAG and EPA used different capital cost factors. Table 4

compares EPA and UWAG unit capital cost estimates on a dollars per 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.

In addition, as previously mentioned, UWAG does not agree with the future industry growth rates assumed in t'he 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 did EPA.[1] The UWAG estimates in Table 4 reflect just the higher capital cost factors and not the 'nigher 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 as compared to the $2.6 billion using the lower assumed growth rate. The ratio of forecasted to actual capital expenditures would then range from 1.52-1.56 as compared with 1.36-1.40.

[1] 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 meant fewer new plants would be built than had previously been expected.

TABLE 3

CAPITAL EXPENDITURES FOR WATER POLLUTION ABATEMENT EQUIPMENT: ELECTRIC UTILITIES (Billions of 1974 Dollars)

EXPENDITURE FORECASTS	1974-1977	1974-1983
EPA - December 1974 (Economic Analysis of Effluent Guidelines Steam Electric Powerplants	1.7-	6.6
UWAG [1] - June 1974 (UWAG Economic Analysis was prepared by National Economic Research Associates, Inc.)	2.6	8.9
ACTUAL FORECASTS		
McGraw-Hill - **November 1979** (Historical Pollution Control Expenditures and Related Data)	1.86	--
DOC - Bureau of Economic Analysis (Capital Expenditures by Business for Pollution Abatement)	1.91	--

[1] 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.

TABLE 4

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	S27.01
For New Units		
Non-Nuclear	S4.89	$6.40
Nuclear	S3.84	S4.27
Chemical Guidelines		
Capacity prior to 1974		
Non-Nuclear	$1.70	$5.78
Nuclear	$0.58	$0.53
Capacity 1974-1978		
Non-Nuclear	S1.29	$4.58
Nuclear	$0.58	$0.53

[1]The estimates are the projected costs to meet the 1377 BPT chemical guidelines.

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, this analysis examines the cost 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 rat'ner 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). The expenditures reported include only 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 by Temple, Barker & Sloane, Inc., in May 1976.[2] Industry estimates were prepared 'oy the National

[1] Utility FGD Costs: Reported and Actual Costs for Operating FGD Systems. PEDCO Environmental, Inc., January 1979.

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

Economic Research Associates.[1] The National Public Hearings on Powerplant Compliance with Sulfur Oxide Air Pollution Regulations provided a third source of cost estimates.[2] All cost estimates and expenditures shown in Table 5 were adjusted to 1977 dollars using the Chemical Engineering index,[3]

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 provides the ratios 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.

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[1] The Cost of Reducing Sulfur Dioxide Emissions from Electric Utility Plants. National Economic Research Associates, 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.

[3] The survey on actual expenditures used this index to convert reported expenditures to 1977 dollars. The EPA study suggested an alternative inflation index; however, the Chemical Engineering index was used to conform with the survey of actual expenditures.

RATIO OF SCRUBBING COST
ESTIMATES TO REPORTED EXPENDITURES

	New Unit Cost	'Retrofit Cost
EPA	.70	.77
National Public Hearings	--	.59-.89
Industry	.84	.96

Using its own cost factors, EPA would have estimated the capital expenditures for the PEDCO 21 plant sample to be 26 percent (or $234 million) less than the actual figure. Using industry unit cost estimates would have resulted in estimated capital expenditures 9 percent (or S81 million) less than the actual figure .[1] The ratios of estimated capital expenditures to reported capital expenditures, provided in Table 1 of the Summary and Overview section of this study, are derived from the estimated capital expenditures and reported capital expenditure's for the 21 plant sample discussed above.

[1]Total capital expenditures for the 21 plants were $1,152 million during the 1970-1978 period.

TABLE 5

COST OF S02 SCRUBBERS ($/KW)
(1977 Dollars)

Expenditure Forecasts	New Unit Cost	Retrofit Cost
EPA - May 1976	**62**[1]	79[1]
Economic and Financial Impacts of Air & Water Pollution Controls on the Electric Utility Industry		
Public Hearings - October 1973	**--**	71-92
National Public Hearings on Power Plant Compliance with Sulfur Oxide Air Pollution Regulations		
Industry - June 1975	74	99
The Cost of Reducing SO_2 Emissions from Electric Utility Plants		
Actual Expenditures		
EPA/PEDCO - September 1978	88	103
Utility FGD Costs: Reported and Adjusted Costs for Operating FGD Systems		

[1]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

Best practical control technology (BPT) 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 the bleat'ned kraft, groundwood, sulfite, soda, de-inked and non-integrated paper segments of the industry,

Methodology and Data Sources

Estimated costs of compliance with BPT regulations were calculated by both the EPA and the pulp and paper industry. These estimates are compared with the actual water pollution abatement expenditures made by t-he industry. All of the cost figures in this section are adjusted to 1975 dollars, using the Bureau of the Census' new plant and equipment price deflator for water pollution abatement equipment.

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 lies in the fact that most of the studies report the estimated expenditures in dollars per ton by subindustry (e.g., bleached kraft; market pulp; papergrade sulfite; soda, de-inked; and so forth) . In order to compare t'nese 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 'oasis have been excluded.

Two EPA studies[1] and the one industry study[2] provide estimates of the industry-wide capital expenditures necessary to meet BPT guidelines on a total dollar basis. These estimates have 'seen adjusted to reflect an 83 percent compliance rate for the industry.[3] It was assumed that the EPA and industry capital cost forecasts to meet the BPT effluent guidelines represent total capital expenditures for water pollution abatement.[4] Further, the industry study predicted capital expenditures only for existing facilities. To make this forecast comparable to the surveys of actual expenditures, the estimated expenditure for new facilities developed in the EPA study was added to the industry forecast.

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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, January 1976, Arthur D. Little, Inc.; 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, Inc., December 1973, prepared for the American Paper Institute.

[3] This compliance rate was developed from compliance data obtained from the EPA Office of Enforcement on paper products, paper mills, and pulp mills.

[4] This assumption is valid because the original industry study prepared by Arthur D. Little, Inc. projected capital expenditures due to BPT as those expenditures in excess of a prior years' baseline expenditure level 'which **was** provided by an industry survey of capital expenditures for water pollution control.

There are four sources which provide information on actual water pollution abatement capital expenditures in the pulp and paper industry. These include the Bureau of the Census,[1] the Bureau of Economic Analysis,[2] McGraw-Hill[3] publications in addition to a National Council of the Paper Industry for Air and Stream Improvement (NCASI) publication on environmental expenditures.[4] These sources were all comparable and no adjustments were necessary.

Cost Comparisons

Table 6 provides the estimated capital costs for water pollution abatement and the reported actual capital expenditures. As the table indicates, EPA projected expenditures are larger than the actual expenditures, while industry forecasts were lower.

The chart below provides the ratio of estimated capital expenditures to actual expenditures for the various forecasts and actual expenditure surveys. The range of ratios reflects comparisons with different expenditure surveys.

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[1] Pollution Abatement Cost and Expenditures, U.S. Bureau of the Census, 1973-1977.

[2] Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis, July 1975, June 1977, February 1979, and June 1979.

[3] Historical Pollution Control Expenditures and Related Data, November 1979, McGraw-Hill Publications Co., Department of Economics.

[4] A Survey of Pulp and Paper Industry Environmental Protection Expenditures - 1978, National Council of the Paper Industry for Air and Stream Improvement, Special Report No. 79-03, September 1979.

RATIO OF ESTIMATED CAPITAL EXPENDITURES
TO REPORTED CAPITAL EXPENDITURES
FOR WATER POLLUTION ABATEMENT

	1974-1977	1972-1977
EPA Estimates		
EPA/ADL	1.36-1.60	--
Cost of Clean	--	1.14
Industry Estimate		
API /ADL	--	.92

The industry estimate is approximately 18 percent below the actual 1972-1977 capital expenditures as they are reported by NCASI and McGraw-Hill.[1] Both of the EPA estimates are slightly higher than the actual expenditures. The forecasted costs reported in the January 1976 study by ADL averaged 48 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.

[1] 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.

TABLE 6

CAPITAL EXPENDITURES FOR WATER POLLUTION ABATEMENT EQUIPMENT: PULP AND PAPER INDUSTRY (millions of 1975 dollars)

	1974-1977	1972-1977
Actual Expenditures	S876.0-$1,028,6[1]	$1,411.2-$1,411.9[2]
EPA Estimates		
ADL - January 1976	1397.4	--
Cost of Clean - Aug. 1979	--	1608.2
Industry Estimates		
ADL - December 1973	--	1,156.4

[1]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.

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

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.

Methodology and Data Sources

The estimates of the cost of compliance with water pollution control regulations 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 Bureau of the Census' new plant and equipment price deflator for water pollution abatement equipment.

[1] Economic Impact of EPA's Regulations on the Petroleum Refinery Industry, Sobotka & Co., Inc., April 1976; and The Cost of Clean Air and Water Report to Congress, August 1979.

[2] The Economic Impact of Environmental Regulations on the Petroleum Industry Phase II Study, Battelle Columbus Laboratories, June 11, 1976.

[3] Water Pollution Control Act of 1972. Economic Impact Pilot Studies, Five Industries, The Conference Board, June 1975.

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 33 percent.[1]

There are four sources of actual water pollution abatement expenditures for the petroleum industry as a whole. These data sources are published by the Bureau of the Census,[2] the Department of Commerce Bureau of Economic Analysis,[3] McGraw-Hill,[4] and the American Petroleum Institute[5] (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 individual sectors of the petroleum industry, allocate water

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

[2]Pollution Abatement Cost and Expenditures, U.S. Bureau of the Census, **1973-1977.**

[3]Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis, July 1975, June 1977, February 1979, and June 1979.

[4]Historical Pollution Control Expenditures and Related Data, McGraw-Hill Publications Co., Department of Economics, November 1979.

[5]Environmental Expenditures of the United States Petroleum Industry 1969-1978, American Petroleum Institute, 1979.

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 the petroleum refining, industry, and. it is this portion of the API data which is reported herein. In order to utilize the remaining two sources of actual data, 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 Bureau of Economic Analysis and the McGraw-Hill publications.

The Bureau of the Census, API , and McGraw-Hill expenditures data are very similar, while t'ne Bureau of Economic Analysis shows slightly larger capital expenditures for water pollution abatement. These data are shown in Table 7.

Cost Comparisons

As is depicted in Table 7, 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 analysis in order to arrive at the minimum estimated cost of compliance with water pollution control requirements .

The chart below provides the ratio of estimated expenditures to actual expenditures for the various forecasts and actual expenditure surveys. The range of ratios reflects comparisons of t'ne cost forecasts with different expenditure surveys.

RATIO OF ESTIMATED CAPITAL EXPENDITURES
TO REPORTED CAPITAL EXPENDITURES FOR
WATER POLLUTION ABATEMENT

	1974-1977	1972-1977
EPA Estimates		
Sobotka	1.87-2.56	--
Cost of Clean	--	1.82-1.84
Industry Estimates		
API/Battelle	1.91-2.62	
National Commission on Water Quality		
Conference Board	--	.89-.90

The EPA studies overestimated capital expenditures by 82-156 percent. The industry forecast overestimated capital expenditures by 91-162 percent. The National Commission on Water Quality underestimated capital expenditures by about 10 percent.

TABLE 7

CAPITAL EXPENDITURES FOR WATER POLLUTION ABATEMENT EQUIPMENT: PETROLEUM REFINING INDUSTRY (millions of 1974 dollars)

	1974-1977	1972-1977
Actual Expenditures	$545.5-$747.8 [1]	**$786.8-$791.6** [2]
EPA Estimates		
Sobotka - April 1976	1,397.5	--
Cost of Clean - Aug. 1979	--	1,444.4
Industry Estimates		
API/Battelle - June 1976	**1,426.7**	--
National Commission on Water Quality		
Conference Board - June 1975	--	707.3

[1] 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.

[2] The lower and upper bounds of the range depict the API and the McGraw-Hill figures respectively".

V. IRON & STEEL INDUSTRY

Introduction

The BPT effluent guidelines for the integrated iron and steel industry established 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.

Methodology and Data Sources

The capital expenditure estimates for water pollution abatement in the iron and steel industry consist of two EPA estimates,[1] one industry estimate,[2] and one estimate from the National Commission on Water Quality.[3] All of the cost figures presented in this section have been converted to 1975 dollars using the Bureau of the Census' new plant and equipment price deflator for water pollution abatement equipment.

[1] Economic Analysis of Proposed and Interim Final Effluent Guidelines, Integrated Iron and Steel Industry, Temple, Barker & Sloane, Inc., March 1976; and Cost of Clean Air and Water Report to Congress, August 1979.

[2] Steel and the Environment: A Cost Impact Analysis, Arthur D. Little, Inc., May 1975, prepared for the American Iron & Steel Institute.

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

In order to compare the cost estimates with actual expenditure data, all the estimates must be adjusted to a consistent basis . In t'ne case of the iron and steel industry studies, a number of adjustments to t'he original estimates were necessary to achieve Such consistency. The methodology used to make t'nese adjustments is described below.

The EPA study prepared by Temple, Barker & Sloane, Inc. (TBS) estimates capital expenditures to meet BPT guidelines. However, TBS did not believe that compliance wi th the 3PT guidelines could be met in 1977 and they provided snot'ner capital expenditure estimate for the 1975-1977 time period. The estimate to meet BPT guidelines, weighted by an appropriate compliance factor, was used in this analysis because it was more comparable to the other cost forecasts and surveys on actual expenditures. It is assumed t'nat the expenditures to meet BPT guidelines represent total water pollution cent ro 1 expenditures during the time period of interest.

Putnam, Hayes & Bartlett, Inc derived t'he industry cost forecasts from the industry study sponsored by the American Iron and Steel Institute. The total capital costs were forecasted by estimating the cost to existing facilities to meet the BPT effluent guidelines and by estimating the costs of water pollution abatement for new facilities built after 1974. The capital requirements for existing facilities to comply with BPT are provided specifically in the industry study.[1] The cost of pollution control for. new facilities is also provided, but it is not divided into costs for air and water pollution control. The portion of costs for water pollution control for

[1]See Figure 1-1 and Table I-2 of the Arthur D. Little, Inc. report "for estimates of capital requirements for existing facilities.

new facilities during 1975-1977 was estimated by prorating the total pollution control costs for new facilities during the 1975-1977 period by the ratio of water pollution control costs to total pollution control costs for new facilities during the 1975-1983 period.[1] Finally, all projected expenditures were weighted by a compliance rate of 54 percent.[2]

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,[3] the Bureau of Economic Analysis[4] (BEA), the American Iron and Steel Institute[5] (AISI), and McGraw-Hill.[6]

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

[1]See Table VI-23 of the Arthur D. Little report for the estimates of total pollution control costs for new facilities, and Table VI-3 for the ratio of water pollution control costs to total pollution control costs for new facilities.

[2]This is the compliance rate for the Iron and Steel Industry as reported by the EPA Office of Enforcement.

[3]Pollution Abatement Cost and Expenditures, U.S. Bureau of the Census, 1973-1977.

[4]Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis, July 1975, June 1977, February 1979, and June 1979.

[5]AISI Statistical Highlights Us. Iron and Steel Industry 1969-197a.

[6]Historical Pollution Control Expenditures and Related Data, McGraw-Hill Publications Co., Department of Economics, November 1979.

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 Census Bureau for 1373 were not divided into air and water pollution control expenditures. To obtain the 1973 total expenditure figure for water pollution control, the total 1973 figure was adjusted by the 1974 ratio of water pollution control expenditures to total expenditures. The data from the four sources differ somewhat and the range of actual capital expenditures is depicted in Table 8.

Cost Comparisons

As is shown in Table 8, all of the earlier estimates of capital expenditures for water pollution control were significantly higher than the actual capital expenditures reported by the four sources of actual pollution control costs, The chart below lists the ratios of estimated to reported capital expenditures for various forecasts and surveys of actual expenditures. The range of ratios reflects comparisons with various expenditure surveys.

RATIO OF ESTIMATED CAPITAL EXPENDITURES
TO REPORTED CAPITAL EXPENDITURES FOR
WATER POLLUTION ABATEMENT

	1975-1977	1973-1977	1972-1977
EPA Estimates			
TBS	1.32-1.79	--	
Cost of Clean	--	--	.55-.85
Industry Estimate			
AISI/ADL	--	1.29-1.96	--
National Commission on Water Quality			
The Conference Board	--	1.23-1.88	--

The EPA forecast prepared by TBS overestimated capital expenditures by 32-79 percent. The industry forecast overestimated capital expenditures by 29-96 percent. 'When comparing estimates with the AISI actual expenditure figure, the most accurate forecast of the capital cost of water pollution abatement was made 'by EPA in the 1979 Cost of Clean Air and Water report'. This estimate of $S93 . 7 million for the years 1972-1977 is 15.2 percent lower than the AISI . actual expenditure figure.

TABLE 8

CAPITAL EXPENDITURES FOR WATER POLLUTION ABATEMENT EQUIPMENT THE IRON AND STEEL INDUSTRY (millions of 1975 dollars)

	1975-1977	1973-1977	1972-1977
Actual expenditures	465.1-630.0[1]	624.3-952.62	699,9-1070.6[3]
EPA Estimates			
T!3S - March 1976	831.6	--	--
Cost of Clean Aug. 79	--	--	593.7
Industry Estimates			
AISI/ADL - May 1975	--	1225.5	--
National Council on 'Water Quality			
Conference Board June 1975	--	1173.6	--

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

[2]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.

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

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 that would 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 that would 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,[1] the National Academy of Sciences,[2] automobile manufacturers as reported in EPA

[1] Automobile Emission Control - The Technical Status and Outlook as of December 1974, U.S. EPA, 1975; The Economics of Clean Air, Annual Report to Congress, U.S. EPA, March 1972; EPA Fact Sheet #1, U.S. EPA, 1978; Automobile Emission Control - The Technical Status and Outlook, U.S. EPA, April 1976.

[2] Semiannual Report by the Committee on Motor Vehicle Emissions, the National Academy of Sciences, 1972, 1974.

control status reports,[1] and by the Council on Environmental Quality.[2] 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.[4]

Cost Comparisons

Table 9 compares actual and estimated sticker price increases due to emission controls. The chart below lists the ratio of estimated price increases to actual price increases for model years 1973-1974, 1975-1976, and 1980. All ratios are based on cumulative estimates of projected price increases and reported sticker price increases. The range of ratios reflects comparisons of various estimates of sticker price increases and reported price increases.

For the 1973-1974 model year the EPA and CEQ estimates are the most accurate, however, both estimates are substantially higher than reported price increases. For the 1975-1976 model year the EPA and NAS estimates are closest to the reported figures. In comparing the EPA cost estimates for the 1980

[1]Automobile Emission Control - The Technical Status and Outlook, U.S. EPA, 1975, April 197,6.

[2]Economic Impact of Pollution Control, Council on Environmental Quality, March 1972.

[3]Preliminary Report on Prices of New Passenger Cars, U.S. Bureau of Labor Statistics, news releases 1971-1979.

[4]U.S. Senate Hearings, May 13, 1975, May 19, 1975, and May 21, 1975.

RATIO OF ESTIMATED TO ACTUAL
STICKER PRICE INCREASES

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	.93-1.20	.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	

model year with the BLS data we find that EPA has underestimated the control cost by 18 percent. This is in contrast to the 1973-1974 model year where EPA overestimated the cost by 32-69 percent.

From analyzing this data, it appears that the EPA estimates are closer to the actual price increases than the manufacturer estimates. The manufacturers' estimates indicate a large degree of variance. One would expect larger manufacturers to produce pollution control systems for their cars at a lower cost than smaller manufacturers because of economies

of scale. However, since individual manufacturer estimates were not available for these emission standards, it is impossible to determine if the manufacturers consistently overestimate or underestimate control costs without knowing which estimates are from the larger manufacturers.

TABLE 9

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	ff3	204	55-364	110-496	209	307
MY 77-79 (1.5/15/2.0)	35	250	--	--	15	215			0-182[8]			
MY do (.41/7.0/2.0)	99	349	--	--	70	" 2ft5			--			
MY 81 (.41/3.4/1.0)	--	--	--	--	150	435			154-378[8] (over NY 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. Iacocca, 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.