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MARTIN MARIETTA

Analysis of the Role of Regulation in the Escalation of Capital Additions Costs for Nuclear Power Plants

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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ANALYSIS OF THE ROLE OF REGULATION IN THE ESCALATION OF CAPITAL ADDITIONS COSTS FOR NUCLEAR POWER PLANTS

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Report Prepared by
SC&A, Inc.
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McLean, Virginia 22102
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operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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ANALYSIS OF THE ROLE OF REGULATION IN THE ESCALATION OF CAPITAL ADDITIONS COSTS FOR NUCLEAR POWER PLANTS

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ABSTRACT

This study examines the role of regulation in the escalation of capital additions costs for nuclear power plants over the past ten years. Unlike previous studies which used a statistical approach to examine the influence of causal factors on the variation in costs, this report is based on actual case studies at four nuclear power plants operated by two utilities. These plants, which are not identified by name, span the entire range of reactor manufacturers.

In addition to the evaluation of the role of regulation on capital additions costs, we also examined the contribution of requirements resulting from the accident at Three Mile Island, and, where possible, the reasons for utility-initiated backfits.

The results indicate that the magnitude of capital additions expenditures are plant-dependent, but that the portion of capital additions costs attributable to regulation (largely NRC-imposed) over the entire period varies only between approximately 34 and 40 percent for pressurized water reactors. For the single boiling water reactor plant examined, the portion attributable to regulation is significantly higher - approximately 65 percent. Since the year 1984, TMI-related expenditures have represented a larger portion of the regulatory-induced capital additions than prior to 1984, but the data indicate that these expenditures may have stabilized. In fact, the data indicate that total expenditures for capital additions may have stabilized over the past few years. However, because of the limited number of plants examined in this study, caution must be exercised in drawing firm conclusions from the results.

1. INTRODUCTION

During 1988, the U. S. Department of Energy's Energy Information Administration (EIA) issued the results of a statistical analysis of nonfuel operating costs for nuclear power plants in this country. The report, An Analysis of Nuclear Power Plant Operating Costs (DOE/EIA-0511), confirmed that there has been significant escalation of real (inflation-adjusted) nonfuel operating costs since 1974 and examined the contributions of various factors (increased costs of replacement power, state regulatory actions, plant aging, and expanded NRC activity) to this escalation.

The EIA report also analyzed the changes of the two components of nonfuel operating costs during the 1974-1984 time period. These components are: 1) routine operating and maintenance expenditures (O&M costs), which are traditionally expensed by a utility (passed through to its customers) in their entirety at approximately the same time they are incurred; and 2) post-construction capital expenditures (capital additions costs), which are included in the utility rate base upon the completion of the work and amortized over time. Capital additions include projects, both large and small, that are required to sustain the original design performance of a generating unit, to improve the performance of a unit, and to modify (backfit) the unit as required by regulators (particularly the Nuclear Regulatory Commission).

According to the EIA report, total real (1982 dollars) nonfuel operating costs increased from $26 per kilowatt-electric (kWe) of installed capacity in 1974 to about $95 per kWe in 1984. In any given year, capital additions costs were shown to constitute a substantial portion of these nonfuel operating costs -- between 26 percent and 45 percent, depending on the year examined. When one considers that capital additions costs escalated at the rate

of about 17 percent per year over the period examined, as compared to about 12 percent per year for O&M costs, the growing importance of the capital additions component is clear. More detailed examination of this component, to determine the principal factors influencing its increase, was considered to be a potentially valuable extension of the EIA work and is the subject of this report.

Unlike the aforementioned EIA effort, which utilized a statistical approach in examining the influence of broad causal factors on the costs experienced across many nuclear units over time, this report is based on case studies of historical costs incurred at five individual units. Furthermore, the current scope was limited to an investigation of capital additions costs, based on explicit information on year-by-year expenditures for individual capital additions projects. Although the case-study approach is unable to identify industry-wide trends, it permits a direct assessment of the contributions to escalating capital additions costs made by factors such as regulation, an assessment which is tenuous when using the statistical approach. In addition, by utilizing cost data for plants of different types, from different utilities, and supplied by different vendors, the case-study approach can be used to postulate trends, although such results are unavoidably limited in value by the size of the sample used.

The major issues addressed in this report are as follows:

- For each of the units examined, what were the capital additions costs incurred as a function of time?

- What portion of these capital additions costs resulted from regulation and what portion was initiated by the utility?

- What portion of the regulatory-imposed capital additions costs resulted from Three Mile Island (TMI) requirements?

- What other causal factors can be reasonably deduced from the results (e.g., PWR vs. BWR effects)?

Section 2 describes the cost data used in the analysis. Section 3 summarizes and discusses the results obtained, and Section 4 presents the conclusions reached concerning trends and major causal factors.

2. UTILITY COST DATA

2.1 Overview

Two utilities provided the data on capital additions costs presented and analyzed in this report. These companies assisted in the study by providing detailed cost records for review, by answering questions concerning definitions of parameters, and by furnishing additional information requested during the course of the analysis.

Prior to the receipt of the data, confidentiality agreements were reached with each utility, which assured the anonymity of the utilities and of the specific plants examined. Accordingly, we have denoted the plants by using a set of codes. We are unable to present the net electrical outputs, commercial operation dates, or Nuclear Steam Supply System vendors, because this information could be used to identify specific plants and would accordingly compromise the confidentiality agreement.

Each utility supplied cost information for two nuclear power plants. Requests were made for yearly expenditures on capital additions for each plant over the period 1978 through 1987, to enable TMI-related regulatory impacts to be estimated (the accident at Three Mile Island occurred in 1979). To facilitate the analysis of cause, we requested descriptive information on each capital addition project along with the costs. However, the level of detail that could be provided by each company differed substantially, owing to differences in their accounting systems.

The two utilities appear to be consistent in their allocation of post-construction, nonfuel costs to either O&M or capital additions accounts. Projects that involve additions, modifications, or repair of plant equipment are considered capital additions;

costs associated with these projects are placed in construction-work-in-progress (CWIP) accounts until the projects are completed, at which point they can be moved into rate base and depreciated with other plant costs. Other post-operational, non-fuel costs -- including engineering studies that do not result in plant modifications -- are included in O&M accounts and are expensed. As a special case, one of the utilities is allowed by its regulatory commission to expense regulatory-induced capital additions projects upon their completion.

Three of the four nuclear power plants examined employ a single pressurized water reactor (PWR) unit. The fourth plant employs two identical boiling water reactor (BWR) units, which have been combined and treated as a single unit for the purposes of this analysis to eliminate certain cost allocation obstacles that are described later. Each of the three PWR units was supplied by a different vendor. This diversity of characteristics among the four plants was intriguing in that it offered the promise of examining influences other than regulation on capital additions costs, although estimation of these effects is not central to the purpose of the study.

It should be noted that the five units included in the study are not among the oldest or newest in the country, nor are they among the least or most expensive in terms of either initial cost or operating cost. In short, they are broadly representative of the majority of units currently in operation within the United States.

2.2 Plant Notation

To facilitate both the description of information received from the utilities and the subsequent discussion of results, the following notation was adopted:

Utility --	A	A	B	B
Plant --	A1	A2	B1	B2
Type --	PWR	BWR	PWR	PWR
Vendor --	PWR-1	BWR	PWR-2	PWR-3

2.3 Description of the Data Obtained

The capital additions cost information provided by the utilities is described below for each plant, including data obtained initially and data supplied in response to follow-up requests.

Plant A1. Data on yearly expenditures for each of 618 projects, ranging in magnitude up to $89 million, were obtained for the years 1978 through 1987. All projects initiated since plant startup were included. The utility's accounting system enabled these projects and their year-by-year expenditures to be assigned to three categories -- NRC-imposed backfits associated with TMI, other NRC-imposed backfits, and utility-initiated backfits. Descriptions of all projects for which expenditures were $250,000 or greater ("major projects") were extracted from the utility's budget request records.

Plant A2. This is a two-unit plant. For each unit, yearly expenditures from 1978 to 1987 were obtained for all projects initiated since the units began commercial operation. (Note that both units were in operation during the entire period.) Data on 277 projects, ranging in magnitude up to $26 million, were obtained for one of the units, while data on 796 projects, ranging in magnitude up to $25 million, were obtained for the other. Many of the projects represented work that was equally applicable to both units; for accounting purposes, these "common" projects and their related expenditures were assigned by the utility to the unit with the earlier commercial operation date.

The utility's accounting system assigned projects for this plant among five categories - regulatory, design deficiencies, reliability, miscellaneous plant improvements, and cost benefits - to satisfy the reporting needs of a minority owner of the plant. As for Plant A1, descriptions of major projects were extracted from budget request records.

Plant B1. The focus of the capital additions accounting breakdown by this utility has been on regulatory-induced expenditures, due to the fact that favorable rate treatment is afforded within that state to costs incurred in complying with regulatory requirements. Annual expenditures on these regulatory-induced projects were obtained for a period that extended from 1987 back through approximately 1980, with a scattering of information on expenditures prior to 1980. Approximately 130 projects were identified, ranging in magnitude up to $16 million. The regulatory initiative that resulted in each project was identified. With only minor exceptions, these were projects resulting from NRC requirements. No information was available on the costs of individual projects which were utility-initiated. However, aggregate annual expenditures covering all capital additions were obtained for the period 1978 through 1987.

Plant B2. The same accounting limitations which apply to Plant B1 are applicable here, and the same type of information was obtained from the utility. Approximately 83 regulatory-induced projects were identified, ranging in magnitude up to approximately $5 million.

The capital additions data obtained from both utilities included the associated allowance for funds used during construction (AFUDC).

3. RESULTS OF THE ANALYSIS AND DISCUSSION

This section describes the procedures and assumptions used to analyze the data on capital additions expenditures and gives the results of the analysis. The results are presented separately for each of the four plants, reflecting the differences in the information obtained.

All cost results are presented in 1982 dollars per kWe of net plant capacity ($/kWe), to eliminate the effects of inflation, facilitate comparisons among plants of different capacity, and to be consistent with usual EIA practice. Conversion of costs from current dollars to 1982 dollars was accomplished using the Implicit Price Deflators for Gross National Product.

3.1 Analysis and Results for Plant A1

The data provided for this plant were better organized than those for the other plants and, therefore, were most readily amenable to analysis. The categorization of projects into NRC- and utility-initiated backfits by the utility was independently reviewed using the individual project descriptions provided by the utility and, with minor exceptions, was judged to be proper.

The annual expenditures for each of the categories were determined by summing individual project expenditures, as were the totals over the 10-year period. Table 1 summarizes this information, but excludes the breakdown of utility-initiated projects, because that breakdown was based on major projects only; the approximate allocation between the utility-initiated sub-categories is presented separately in Table 2.

TABLE 1

CAPITAL ADDITIONS - PLANT A1
(1982 $/kWe)

Year	TMI	Regulatory-Induced Other	Total	Utility-Initiated	Annual Total	% Reg-induced
1978	0.00	5.83	5.83	3.70	9.53	61.2
1979	0.00	8.69	8.69	1.75	10.44	83.2
1980	4.63	13.55	18.18	2.34	20.52	88.6
1981	4.07	3.32	7.40	11.18	18.58	39.8
1982	2.16	5.00	7.16	17.72	24.89	28.8
1983	3.72	12.72	16.44	59.41	75.86	21.7
1984	10.77	19.34	30.11	131.65	161.76	18.6
1985	8.73	25.56	34.29	29.01	63.31	54.2
1986	9.42	18.03	27.45	45.60	73.05	37.6
1987	11.08	1.51	12.59	20.98	33.57	37.5
Total	54.58	113.56	168.14	323.36	491.50	34.2

% of regulatory-induced caused by TMI = 32.5%

For 1984-1987 only:
% of total that was regulatory-induced = 31.5%
% of regulatory-induced caused by TMI = 38.3%

TABLE 2

UTILITY-INITIATED CAPITAL ADDITIONS -
PLANT A1*
(1982 $/kWe)

Year	Repair	Betterment	Total	% Betterment
1978	0.05	2.37	2.43	97.8
1979	0.08	0.89	0.97	92.1
1980	0.68	0.56	1.24	45.1
1981	8.20	2.07	10.28	20.2
1982	15.50	0.72	16.22	4.5
1983	50.24	7.21	57.45	12.5
1984	120.58	9.16	129.74	7.1
1985	10.12	16.51	26.63	62.0
1986	27.08	17.13	44.21	38.7
1987	12.72	7.34	20.06	36.6
Total	245.27	63.96	309.23	20.7

* Includes only projects larger than $250,000

The breakdown of the utility-initiated projects into repair and betterment sub-categories given in Table 2 is limited to those projects for which descriptions were obtained, i.e., those greater than $250,000 in cost. By reviewing those descriptions and making judgments regarding their allocation to either repair or betterment, an approximation of the split between these two subcategories could be made.

As shown in Table 1, the total of all capital additions expenditures over the 10-year period was approximately $491/kWe, with 34.2 percent attributable to regulation. 32.5 percent of the regulatory-induced expenditures resulted from Three Mile Island.

Table 2 indicates that approximately 20.7 percent of the total utility-initiated project expenditures over the 10-year period was associated with projects carried out to improve the overall performance of the plant beyond its initial design level.

Significant variations in expenditures from year-to-year exist in most of the categories examined, which is not surprising when one considers that certain projects were far more costly than others and frequently were carried out over relatively short periods of time. This can be seen with the aid of Table 3, which lists the five largest projects carried out during the period in each of the four categories examined. For example, it is clear that the large expenditures associated with the replacement of steam generators near the middle of the period had a profound effect on the utility-initiated (and utility repair) results for the years 1983 and 1984. Although Table 3 lists only a small number of the projects carried out during the period, it gives an indication of the types of work performed in each category.

Several of the largest projects included in Table 3 are described below, based on the information provided by the utility.

TABLE 3

MAJOR CAPITAL ADDITIONS PROJECTS - PLANT A1

Category	Project	Span	Cost ($000)*
Regulatory TMI	Install emergency response data system	1983-87	13,546
	Install new post-accident instrumentation	1985-87	10,336
	Install reactor vessel level instrumentation	1980-86	3,646
	Construct EOF/TSC/training building	1982-86	2,450
	Upgrade radiation monitoring system	1985-87	1,672
Regulatory Other	Install volume reduction/ solidification system	1982-87	38,854
	Install alternate emergency power source for dedicated shutdown	1980-86	14,349
	Modify fire protection systems	1978-83	11,595
	Purchase spent fuel cask	** -79	4,476
	Expand spent fuel storage	1980-84	3,993
Utility Repair	Install 3 new steam generators	1981-85	89,126
	Modify steam generator support system	1982-85	39,416
	Replace 2 turbine rotors	1986-87	23,843
	Reduce condenser in-leakage	1979-82	5,757
	Renovate misc. plant facilities	1985-87	3,674
Utility Betterment	Modify plant security system	1983-87	14,349
	Install PWR simulator	1984-87	10,423
	Construct new chemistry lab	1982-86	3,140
	Upgrade misc. plant facilities	1983-84	2,932
	Construct simulator building	1984-87	2,335

* Sum of current dollars
** Project began prior to 1978

Install volume reduction/solidification system. A volume reduction, solidification, and drum handling system was installed in a new building. This project was necessary to reduce the volume of waste requiring disposal, so that the inability to dispose of waste would not impact plant operation. The new system was required to meet future Federal and state burial volume constraints.

Install three new steam generators. Deterioration of steam generator tubes dictated that the existing three steam generators be removed and replaced with new steam generators in order to maintain generating capability.

Modify steam generator support system. To provide adequate protection of the steam generators, a condensate polishing system and a makeup water system were installed. Modifications of the feedwater heater system were also made.

3.2 Analysis and Results for Plant A2

Capital additions expenditures for this plant were estimated by combining the data for its two units. This eliminated the potentially difficult problem of assigning costs to one or the other unit which were identified as being common to both. However, since the two units are identical in design, little additional information would have been gained by maintaining their separate identities.

Projects in four of the categories specified by the utility for this plant -- design deficiencies, reliability, miscellaneous plant improvements, and cost benefits -- were combined into the utility-initiated category. No further breakdown of this category was carried out, owing to the fact that the yearly expenditures for each of the projects (almost 950 of them, in this case) were not provided by category. The fifth category of projects

was broken down into sub-categories of TMI-induced and other-regulatory-induced, based on a detailed review of the individual project descriptions available. As with Plant A1, the utility's allocation of projects among the various categories was subjected to an independent review using the project descriptions, and was found to be reasonable.

Table 4 presents the results for Plant A2. The total capital additions expenditures over the 10-year period 1978 to 1987 was determined to be approximately $335/KWe. Of this total, 65.4 percent was found to be the result of regulation, with a fairly consistent level of regulatory impact on a year-to-year basis -- the lowest percentage in any given year is 48.8 percent. The total regulatory-induced expenditures for the entire period were found to be approximately $219/kWe, of which 32.8 percent resulted from TMI requirements.

Year-to-year variations in expenditures were not as dramatic as for Plant A1, but existed nevertheless, with a peak occurring in 1983 due to a confluence of expenditures on large projects -- both regulatory-induced and utility-initiated. Table 5 provides descriptions of the five projects in each category that were most costly to the utility. A number of large regulatory-induced projects that are BWR-specific can be noted. Total project costs are given for each unit, where appropriate; in those cases where a project was common to both units, a "1/2" designation is given.

The largest projects listed in Table 5 are described below, using information obtained from the utility.

Modify torus integrity. Plant-specific torus modifications were required to meet NRC structural acceptance criteria under hydrodynamic loads defined during an analytical and testing program conducted by utility owners of the BWR Mark I design.

TABLE 4

CAPITAL ADDITIONS - PLANT A2
(1982 $/kWe)

Year	TMI	Regulatory-Induced Other	Total	Utility-Initiated	Annual Total	% Reg-induced
1978	0.00	4.90	4.90	1.19	6.09	80.5
1979	0.00	10.48	10.48	5.00	15.48	67.7
1980	1.14	19.78	20.92	8.13	29.05	72.0
1981	1.77	8.49	10.26	10.77	21.03	48.8
1982	7.03	20.49	27.52	14.00	41.52	66.3
1983	11.48	27.87	39.35	28.50	67.86	58.0
1984	6.44	23.73	30.18	19.09	49.27	61.3
1985	18.59	11.25	29.83	8.75	38.58	77.3
1986	17.84	8.74	26.58	9.90	36.48	72.9
1987	7.64	11.72	19.36	10.65	30.01	64.5
Total	71.92	147.46	219.37	115.97	335.35	65.4

% of regulatory-induced caused by TMI = 32.8%

For 1984-1987 only:
% of total that was regulatory-induced = 68.6 %
% of regulatory-induced caused by TMI = 47.7%

TABLE 5

MAJOR CAPITAL ADDITIONS PROJECTS - PLANT A2

Category	Project	Unit	Span	Cost ($000)*
Regulatory TMI	Install emergency response data system	1	1983-87	16,744
		2	1983-87	16,501
	Upgrade non-interruptible air system	1	1984-87	16,351
		2	1984-87	14,050
	Construct EOF/TSC/training building	1/2	1982-85	7,985
	Modify hydrogen control penetrations	1	1980-87	5,837
		2	1980-86	3,762
	Upgrade containment hydrogen monitoring	1	1980-85	5,131
		2	1980-86	5,125
Regulatory Other	Modify torus integrity	2	1980-86	25,844
		1	1980-85	25,148
	Reduce circulating water system environmental impacts (EPA)	2	1980-87	22,301
		1	1980-86	10,361
	Improve fire protection systems	1	1983-87	20,308
		2	1983-87	19,421
	Modify off-gas system	2	1980-86	17,571
		1	1980-86	15,464
	Improve off-gas charcoal absorption system	1	1981-85	9,283
		2	1981-85	7,323
Utility-Initiated	Replace condenser tube sheets	2	1978-85	18,508
		1	1980-85	15,722
	Replace portions of service water piping	2	1980-86	16,060
		1	1982-86	10,640
	Modify liquid radwaste system	1/2	1980-87	9,779
	Install BWR simulator	1/2	1981-83	8,112
	Replace small diameter service water piping	2	1983	4,976
		1	1984	4,551

* Sum of current dollars

Reduce circulating water system environmental impacts (EPA). Modifications of the circulating water system were made to minimize the environmental impacts associated with the impingement and entrainment of marine life at the plant intake structure. This project included: installation of control facilities for safe, reliable operation at reduced circulating water flow rates; modifications to the existing intake screens and screen wash system to increase the survival of impinging fish; installation of a permanent fish diversion screen facility at the entrance to the intake canal; and installation of a fish return system to return the fish to their natural environment. Discussions with the EPA indicated a willingness on the part of the agency to consider the above additions and modifications in lieu of cooling towers, resulting in substantial savings as compared with the cost of installing and operating towers.

Improve fire protection systems. Compliance with NRC requirements necessitated that the utility: install fire barriers, fire doors and walls, fire suppression systems, fire detectors and alarms, manual control stations, an oil separator system, and portable fire fighting equipment; modify ventilation systems; and separate and relocate conduits.

Replace condenser tube sheets. Improvement of condenser integrity was necessary to increase plant availability and reduce operating costs of the condensate demineralizers. As a result, the original condenser tubes were replaced with titanium tubes, and the existing tube sheets were replaced with an "integral double tube sheet" design that included a tube sheet pressurization system.

3.3 Analysis and Results for Plant B1

This utility operates two PWRs supplied by different vendors. Because its cost accounting system was not computerized until the

year 1984, the information provided on project expenditures incurred prior to 1984 was deemed to be insufficiently reliable to be included in the analysis.

The considerable detail provided on regulatory-related projects enabled a breakdown into TMI- and other-regulatory-induced subcategories for the period 1984 to 1987. Although details were not available on individual utility-initiated projects, the yearly expenditures throughout this period were used to calculate the composite expenditures for utility-initiated projects in each year by backing out the total regulatory-induced expenditures.

Table 6 presents the results for Plant B1 and indicates that, over the four-year period, total capital additions expenditures were approximately $136/kWe. Of this amount, approximately $53/kWe -- or roughly 39 percent -- can be attributed to regulation. A relatively high percentage (approximately 59 percent) of the total regulatory-induced expenditures was estimated to be induced by TMI- related regulations. Table 7 lists the five largest projects in each of the regulatory sub-categories and includes projects which incurred costs prior to 1984 for comparison with comparable tabulations for the other plants.

The information provided by the utility did not enable more detailed descriptions of projects undertaken for either Plant B1 or Plant B2.

3.4 Analysis and Results for Plant B2

The approach followed in the analysis of the data for this plant is similar to that adopted for Plant B1. Again, the period examined was constrained to the years 1984 through 1987.

Table 8 shows that the total expenditures on capital additions during the four-year period were approximately $95/kWe and that approximately 40 percent of these expenditures can be attributed

TABLE 6

CAPITAL ADDITIONS - PLANT B1
(1982 $/kWe)

Year	TMI	Regulatory-Induced Other	Total	Utility-Initiated	Annual Total	% Reg-induced
1984	11.87	9.44	21.31	21.11	42.41	50.2
1985	3.23	7.29	10.52	16.89	27.41	38.4
1986	14.96	3.34	18.30	21.55	39.85	45.9
1987	0.99	1.84	2.83	24.04	26.87	10.5
Total	31.05	21.90	52.96	83.59	136.55	38.8

% of Regulatory-induced caused by TMI = 58.6%

TABLE 7

MAJOR CAPITAL ADDITIONS PROJECTS - PLANT B1

Category	Project	Span	Cost ($000)*
Regulatory TMI	Install emergency feedwater system	1980-86	16,323
	Improve post-accident sampling system	1981-84	5,804
	Install reactor vessel level system	1983-87	4,710
	Upgrade gaseous effluent radiation monitoring	1980-85	3,248
	Install reactor cooling system hotleg level indicator	1986-87	3,056
Regulatory Other	Upgrade fire barriers	1983-85	4,501
	Install ATWS data collection system	1984-87	4,547
	Construct low-level radioactive waste storage facility	1982-87	4,063
	Modify fire protection system	1979-82	1,641
	Modify steam piping	1982-84	1,514

* Sum of current dollars

TABLE 8

CAPITAL ADDITIONS - PLANT B2
(1982 $/kWe)

Year	TMI	Regulatory-Induced Other	Total	Utility-Initiated	Annual Total	% Reg-induced
1984	2.22	7.21	9.43	12.76	22.19	42.5
1985	3.86	10.64	14.51	14.84	29.35	49.4
1986	7.87	2.80	10.67	9.55	20.22	52.8
1987	0.90	2.08	2.98	20.34	23.32	12.8
Total	14.86	22.73	37.59	57.48	95.07	39.5

% of Regulatory-induced caused by TMI = 39.5%

to regulation. Three Mile Island was the cause of approximately 40 percent of the total regulatory-induced expenditures during the period. Table 9 lists the five largest projects in each of the regulatory sub-categories.

A comparison of Tables 3, 5, 7 and 9 shows significant diversity among the plants in their largest TMI-induced projects. This is not surprising in that the work required to conform with TMI-related requirements has differed from plant to plant; also, the timing and extent of the effort to conform with these requirements has varied from one utility to the next. The scope of work associated with a given project often varies from one utility to the next, as well.

TABLE 9

MAJOR CAPITAL ADDITIONS PROJECTS - PLANT B2

Category	Project	Span	Cost ($000)*
Regulatory TMI	Improve post-accident sampling system	1979-84	4,786
	Install reactor vessel monitoring system	1983-87	4,621
	Install critical functions instrumentation	1982-84	1,845
	Modify piping systems	1986-87	1,325
	Improve reactor cooling system venting	1979-82	1,093
Regulatory Other	Upgrade fire barriers	1983-85	5,397
	Install ATWS data collection system	1984-87	4,547
	Construct low-level radio-active waste storage facility	1982-87	4,063
	Replace emergency feedwater isolation valves	1982-84	1,154
	Modify snubbers	1985-86	1,032

* Sum of current dollars

4. CONCLUSIONS

Table 10 summarizes certain of the key results for each of the four plants examined. Figure 1 shows the yearly variation of total capital additions expenditures for the plants over the time periods considered.

Because of the limited number of plants included in these case studies, it is a tenuous matter to draw firm conclusions from these results. This is especially true in judging whether the results are applicable to the industry as a whole. However, certain trends appear in Table 10 and Figure 1 that are worthy of mention. These are listed below:

1. Projects that are regulatory-induced have constituted a larger portion of overall capital additions costs for the BWR plant (approximately 65 percent) than for the three PWR plants (in the range of 34 to 40 percent).

2. Since 1984, TMI-related projects have represented a larger portion of overall regulatory-induced capital additions costs than prior to 1984. This might have favorable implications for the future, for two reasons: first, non-TMI regulatory induced expenditures have stabilized -- or have been decreasing -- over the past few years, as shown in Figure 2; and second, one would expect TMI-related expenditures to disappear over the near term. Although the non-TMI regulatory component will likely remain, at varying levels, throughout the life of any U.S. unit, there is no reason to expect the occurrence of a future event having the unique impact of the TMI accident.

3. The level of capital additions costs varies from utility to utility and, for a given utility, between PWR vendors. Major repair jobs will, of course, always

TABLE 10

CAPITAL ADDITIONS - COMPARISON OF PLANTS

(Costs in 1982 $/kWe)

	Plant			
Item	A1	A2	B1	B2
Utility	A	A	B	B
Type	PWR	BWR	PWR	PWR
Vendor	PWR-1	BWR	PWR-2	PWR-3
For 1978-1987:				
Total costs	491.50	335.35		
Reg-induced costs	168.14	219.37		
% reg-induced	34.2	65.4		
TMI % of reg-induced	32.5	32.8		
For 1984-1987:				
Total costs	331.69	154.34	136.55	95.07
Reg-induced costs	104.44	105.95	52.96	37.59
% reg-induced	31.5	68.6	38.8	39.5
TMI % of reg-induced	38.3	47.7	58.6	39.5

Figure 1
TOTAL CAPITAL ADDITIONS COSTS BY YEAR

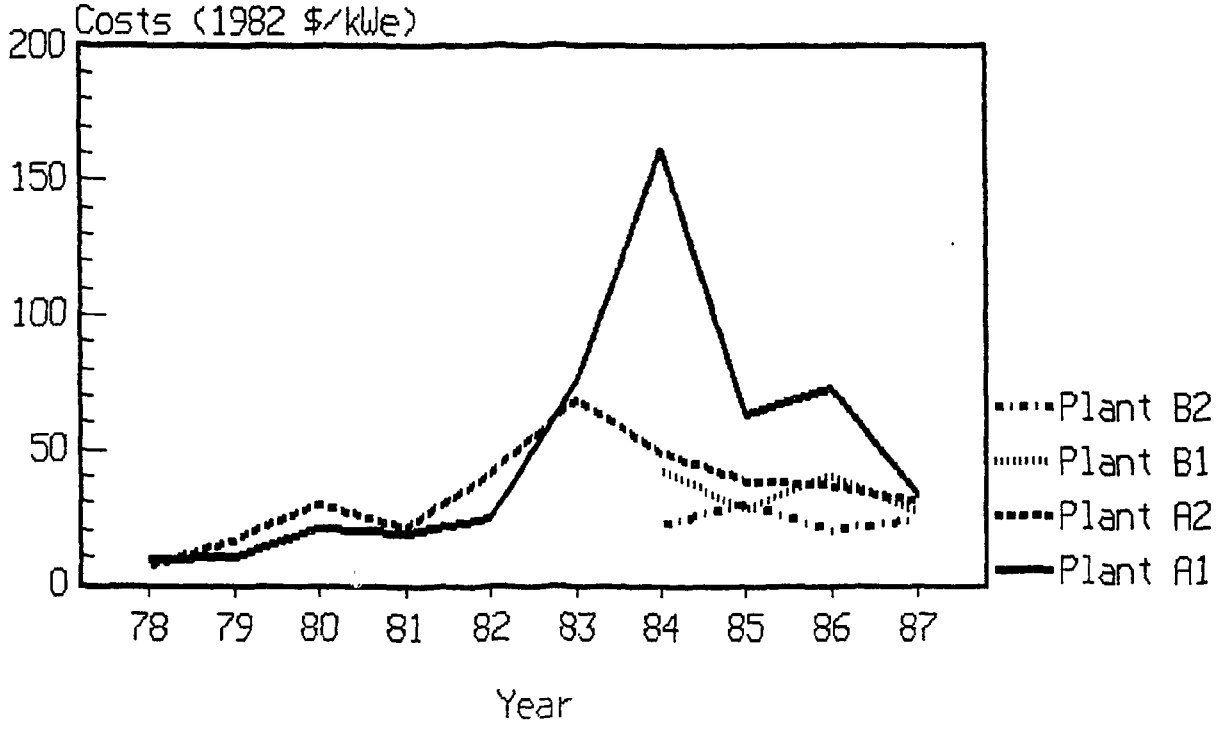
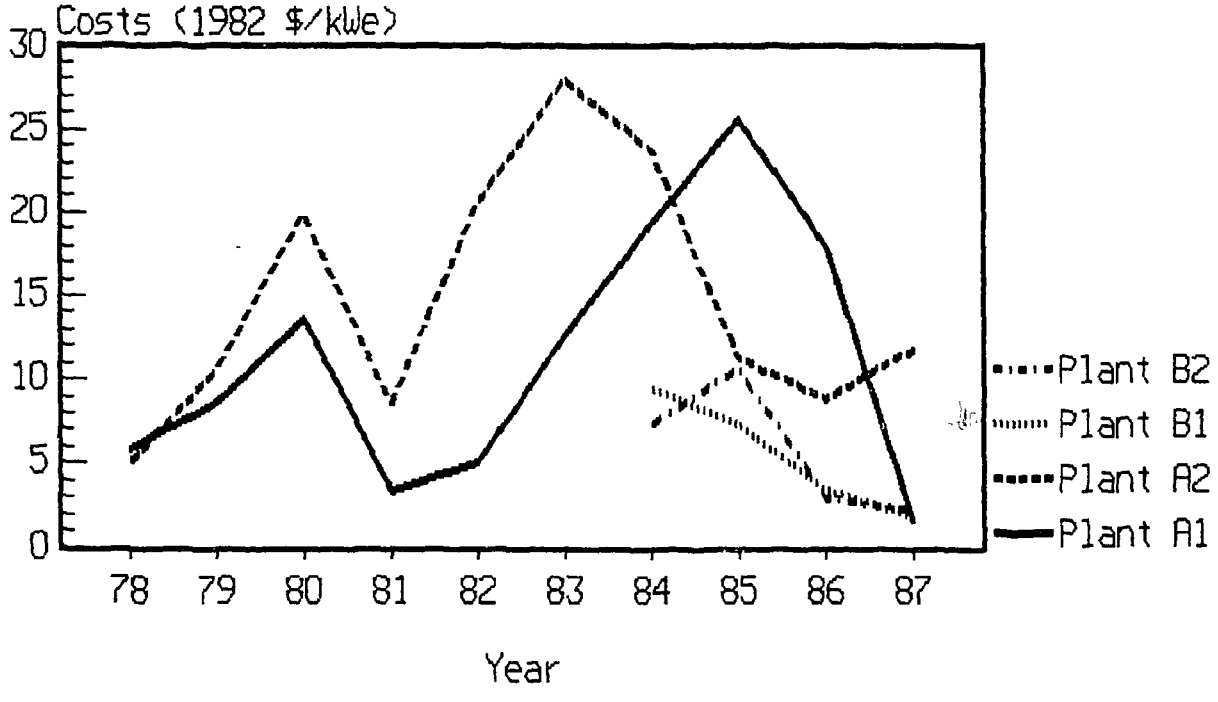


Figure 2
NON-TMI REGULATORY-INDUCED CAPITAL
ADDITIONS COSTS BY YEAR



create major differences in capital additions expenditures; however, these utility- and vendor-dependent differences seem to be in evidence even without the effects of major repairs.

4. Figure 1 shows that total expenditures for capital additions have stabilized, or even decreased, over the past few years. The dramatic "spike" in the results for Plant A1 in 1984 is due, in large part, to the costs of replacing three steam generators (see Table 3). If the expenditures for this single project are removed from the yearly totals for Plant A1, the total cost curves would be as shown in Figure 3. Significant differences still are evident, but the general reduction in the recent expenditures for these plants is more evident.

It would be advisable to include data for 1988 in the analysis, when they become available. In particular, the trend discussed in the previous paragraph could be examined in a more meaningful way. Attempts might also be made to obtain information on the capital additions costs incurred by other utilities, in an attempt to gain further insights into the reasons for their variations over the past decade.

Another potentially useful extension of the analysis would be to include newer units, i.e., units that entered commercial operation during the early-to-mid 1980's, to determine whether the variation of yearly capital additions costs that were regulatory-induced or required to repair the units would differ significantly from the results presented in this report. One might expect that the stabilizing trend shown in non-TMI, regulatory-induced expenditures would be demonstrated by newer units, as well. Furthermore, newer units should benefit from reduced utility-initiated expenditures as the industry learns from problems encountered in operating older units.

Figure 3
TOTAL CAPITAL ADDITIONS COSTS BY YEAR
(W.O. REPLACEMENT OF STEAM GENERATORS)

Internal Distribution

1-2. D. J. Bjornstad
3. J. J. Coen
4. J. G. Delene
5. E. C. Fox
6. L. C. Fuller
7. J. A. Getsi
8. R. S. Holcomb
9-17. C. R. Hudson
18. H. E. Trammell
19. K. A. Williams
20. ORNL Patent Office
21. Central Research Library
22. Document Reference Section
23-24. Laboratory Records Department
25. Laboratory Records (RC)

External Distribution

26. Office of Assistant Manager for Energy Research and Development, Department of Energy, Oak Ridge Operations, Oak Ridge, TN 37831
27. R. A. Diedrich, EI-532, BF-115/FORS, Energy Information Administration, Department of Energy, Washington, DC 20585
28. M. Gielecki, EI-532, BF-115/FORS, Energy Information Administration, Department of Energy, Washington, DC 20585
29-38. J. G. Hewlett, EI-532, BF-115/FORS, Energy Information Administration, Department of Energy, Washington, DC 20585
39. B. O'Brien, EI-532, BG-041/FORS, Energy Information Administration, Department of Energy, Washington, DC 20585
40. H. L. Walton, EI-53, BG-057/FORS, Energy Information Administration, Department of Energy, Washington, DC 20585
41-50. Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831