THE COSTS AND BENEFITS OF RETIRING THE YANKEE ROWE NUCLEAR PLANT

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EXECUTIVE SUMMARY

This study examines the costs and benefits of retiring the Yankee Rowe nuclear plant, and economic claims about the plant made by opponents of a ballot initiative (Question 4) that, if passed, would require the Rowe and Pilgrim nuclear plants to be closed by July 4, 1989. The study found that:

1. Yankee Rowe represents only 0.77 percent of the region's electricity supply. No utility in Massachusetts or elsewhere relies on Rowe for more than 1.12 percent of its power supplies.

2. Contrary to ads sponsored by the No on 4 Committee, Yankee Rowe electricity does not cost "less than 5 cents per kilowatt hour." Rowe electricity cost 5.2 cents per kWh in 1987, and over 5 cents per kWh in five of the last seven years.

3. Operation and maintenance costs at Yankee Rowe are over three times the national nuclear average per kilowatt of capacity, and the second highest in the nation.

4. Yankee Rowe electricity will likely cost between $196 million to $357 million (net present value) more than utility projections of replacement power costs between 1989 and Rowe's scheduled retirement in the year 2000. Other replacement power sources -- such as cogeneration, small renewable energy power plants and energy efficiency investments -- are available which would be even less expensive and environmentally preferable.

5. Even if ratepayers fully compensated Yankee Atomic for its investment in the plant -- including the company earning the same profit on its investment that it would have earned had the plant operated -- ratepayers would save $114 million to $267 million (net present value) by retiring Rowe immediately.

1. Introduction

The Yankee Rowe nuclear power plant, located in the town of Rowe in western Massachusetts, is the oldest operating commercial nuclear plant in the United States. The day after President Dwight Eisenhower signed the Atomic Energy Act in 1954, New England utilities met to begin planning for Yankee Rowe. Construction began in March, 1958, and was completed in June, 1960.[1] A 174 MW* Pressurized Water Reactor, Rowe is the nation's second smallest commercial nuclear plant, larger only than Michigan's 63 MW Big Rock Point plant, completed in 1962.[2]

Recently, the costs and benefits of the Rowe plant have become the subject of considerable debate, largely as the result of an initiative on the November 8, 1988 ballot (Question 4) that would close both Rowe and the Pilgrim nuclear plant, in Plymouth.**

The state's electric utility companies have funded an extensive advertising campaign, through the "No on 4 Committee," focusing largely on the economics, as well as the safety record, of the Yankee Rowe plant. The ads claim that:

* Yankee Rowe produces over 1 billion kilowatt hours of electricity per year, and closing Pilgrim and Rowe would cost the state 20 percent of its power supply.

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*Based on the maximum dependable capacity, as determined by audits for the New England Power Pool. Rowe is rated at 167 MW during the summer, because of warmer cooling water supplies. The nameplate rating, or design electrical capacity is 186 MW, but producing this amount of net power is not routinely achievable in practice.

**Question 4 would prohibit the operation of commercial nuclear plants which generate electricity by means which result in the creation of nuclear waste in Massachusetts after July 4, 1989. Pilgrim and Rowe would be required to close or to convert to non-nuclear fuel sources.

* The cost of electricity from Rowe is less than 5 cents per kilowatt hour (kWh), making Rowe an inexpensive source of electricity.

* Closing Rowe and Pilgrim would constitute a taking of private utility property, thereby requiring compensation by the state, and creating an enormous tax burden on the Commonwealth.

Initiative proponents, on the other hand, have asserted that Rowe is the third most expensive nuclear plant to operate and that it is more expensive than available alternatives.

This report investigates Yankee Rowe economics. Chapter 2 looks at the contribution of Yankee Rowe to the state and regional power supply. Chapter 3 examines the plant's historical costs from 1970 through 1987. Chapter 4 projects likely future costs at the nuclear plant. Chapter 5 examines the cost of retiring Rowe, including the cost of replacement power, compensation and decommissioning the nuclear plant. Chapter 6 summarizes the economic findings and conclusions.

2. Yankee Rowe's Contribution to State and Regional Power Supply

Since 1975, Yankee Rowe has produced an average of 1.08 billion kilowatt hours per year, operating at an average of 70.8 percent of its rated capacity.[3] The electric utilities assert that closing Yankee Rowe and Pilgrim would cut off 20 percent of the state's electricity supply. By their calculations Rowe contributes 4 percent of the state's electricity supply.

While Rowe does represent approximately 4 percent of utility power plant capacity located within Massachusetts' borders, the location of power plants is not a significant factor in measuring contribution to power supply. Virtually all utilities in New England are interconnected in one large power grid, known as the New England Power Pool ("NEPOOL"). Rowe represents just 0.77 percent of NEPOOL's 1988 power plant capacity.[4]

In important respects, NEPOOL operates as one large regional utility. In addition to regional power supply forecasting and planning, NEPOOL coordinates regional plant operations to ensure that, as the region's power demand changes moment by moment, the power plants with the lowest operating costs are used first, regardless of which retail company owns or operates them. Power from each operating plant is distributed to meet the needs of all utilities on the grid. If the power pool were to have inadequate capacity to meet the regional demand for electricity, all companies would share equally in cutbacks.

With Yankee Rowe, NEPOOL expects to have a 23.6 percent reserve margin of power plant capacity above the peak demand forecast for summer of 1989. Without Rowe, the region's reserve margin would be reduced to 22.6 percent.[5] To help meet unexpected demand from extreme weather conditions or to compensate for inoperative plants, a 15 - 20 percent reserve margin, is generally considered adequate to maintain reliable electrical service in a large utility system with well-maintained power plants.[6]

NEPOOL calculates how much power each utility must supply in order for the region to meet the peak demand plus reserve margin. Each company then decides how many and what types of power plants to invest in or purchase power from in order to meet its regional responsibility. If a company has less capacity than required of it, it must purchase replacement capacity, or pay a penalty to the power pool.

The Yankee Rowe plant is owned by the Yankee Atomic Company, a Framingham-based company that is in turn owned by eight private utilities and a group of Connecticut municipal electric companies (Table 1). All of Rowe's electricity is sold at wholesale through firm power contracts to these utilities, who also own all of Yankee Atomic stock. Because Rowe's electricity is sold at wholesale, its rates are regulated by the Federal Energy Regulatory Commission (FERC). Yankee Atomic does not sell any electricity directly to retail customers.

Table 1
Yankee Rowe Ownership and Contribution to Utility Supply

Utility (and Mass. subsidiaries)	States served	Percent of Rowe owned	Percent of utility's 1988 power supply
Boston Edison	Mass.	9.5	0.73
Central Maine Power	Maine	9.5	1.08
Commonwealth Energy (Commonwealth Electric) (Cambridge Electric)	Mass.	4.5	1.06
Conn. Municipals	Conn.	1.1	0.84
Eastern Utilities Assoc. (Eastern Edison Co.)	Mass., R.I.	4.5	0.99
New England Electric (Mass. Electric)	Mass., R.I., N.H.	30.0	1.12
Northeast Utilities (Western Mass. Electric)	Mass., Conn.	30.4	0.81
Public Service of N.H.	NH.	7.0	0.90
Central Vermont Pub. Serv.	Vt.	3.5	0.77

Source: New England Power Pool (NEPOOL) Forecast of Capacity, Energy, Loads and Transmission 1988 - 2002, April, 1988.

Only 44.7 percent of the contractual output of the Rowe plant actually serves Massachusetts customers, according to the Massachusetts Executive Office of Energy Resources.[7] If Yankee Rowe is closed by the ballot initiative, the region will lose only about one percent of its electricity supplies -- even assuming the power could not be replaced from elsewhere. Moreover, because Rowe ownership is distributed among so many companies, no individual utility in Massachusetts or elsewhere will lose more than 1.12 percent of the power it owns or contracts for.

3. Yankee Rowe Historical Cost and Performance

The No on 4 Committee ads represent Yankee Rowe as generating electricity for less than 5 cents per kWh. In 1987, however, Yankee Rowe electricity cost 5.2 cents per kilowatt hour. Rowe electricity has cost more than 5 cents per kilowatt hour in five of the last seven years (Table 2). The average cost for each of the seven years was 5.1 cents per kWh.

Table 2
Yankee Rowe Annual Cost (1981 - 1987)

Year	Total Revenues (million dollars)	Generation (billion kWh)	Cost (Cents per kWh)
1981	46.7	.884	5.3
1982	52.1	.882	5.9
1983	53.7	1.343	4.0
1984	60.5	1.026	6.0
1985	62.4	1.182	5.3
1986	55.0	1.393	4.0
1987	59.0	1.135	5.2

Source: FERC Form 1

In its earliest days, Rowe was a much less expensive source of power, although it was not always less expensive than alternatives. In a 1970 publication, Yankee Atomic indicated that Rowe's power costs from 1961 to 1969 was generally in the range of about 9 to 12 mills per kWh (0.9 to 1.2 cents). Compared to 1969 Rowe costs of 9.0 mills, however

> a conventional plant of the same size, built at the same time, would have power costs of about 8.0 mils (sic), only slightly lower than Yankee's present costs and within the range of possible additional improvements in the future.[8]

The cost of generating electricity at Yankee Rowe, as at all power plants, has increased over time. Power costs are primarily determined by four major factors:

1. **Capital-related costs:** Carrying charges on power plant capital investments are like mortgage payments and taxes on a house. They include a return on capital investment in the plant (interest and profits), depreciation

charges, state and federal income taxes, property taxes, and decommissioning -- dismantling the plant at the end of its useful life. Capital investment includes plant construction costs, as well as the cost of additions, improvements and major repairs, and an inventory of nuclear fuel.

2. **Operation and maintenance (O&M) costs:** These costs include the routine expenses to keep a plant running, such as labor, engineering and outside consulting services, routine materials, and water supplies. O&M overhead costs include property insurance, employee pensions and benefits, and administrative expenses.

3. **Fuel costs:** These include waste disposal, as well as annual fuel burnup costs for nuclear plants.

4. **Capacity factor:** This is the percent of electricity that a plant generates compared to what it is capable of producing if it ran at full power for every hour in the year. How much electricity a plant actually produces in a given year has a major effect on the cost per each kilowatt hour of electricity generated, since total annual nuclear costs vary little with output.

Yankee Rowe was built for a capital cost of $43.7 million. Capital additions have increased total investment in the plant to $81.7 million by the end of 1987. However, through annual depreciation charges, all but $13.7 million has already been recovered from ratepayers, with the plant scheduled to be fully depreciated by the end of 1990. In addition, at the end of 1987 Yankee Atomic had a $27.7 million unrecovered investment in nuclear fuel, for a total investment of $42 million.[9]

Capital additions at Rowe from 1970 to the present averaged about $3.4 million per year in inflation-adjusted dollars. If an exceptionally high figure for 1982 were excluded, the average for the remaining years would be

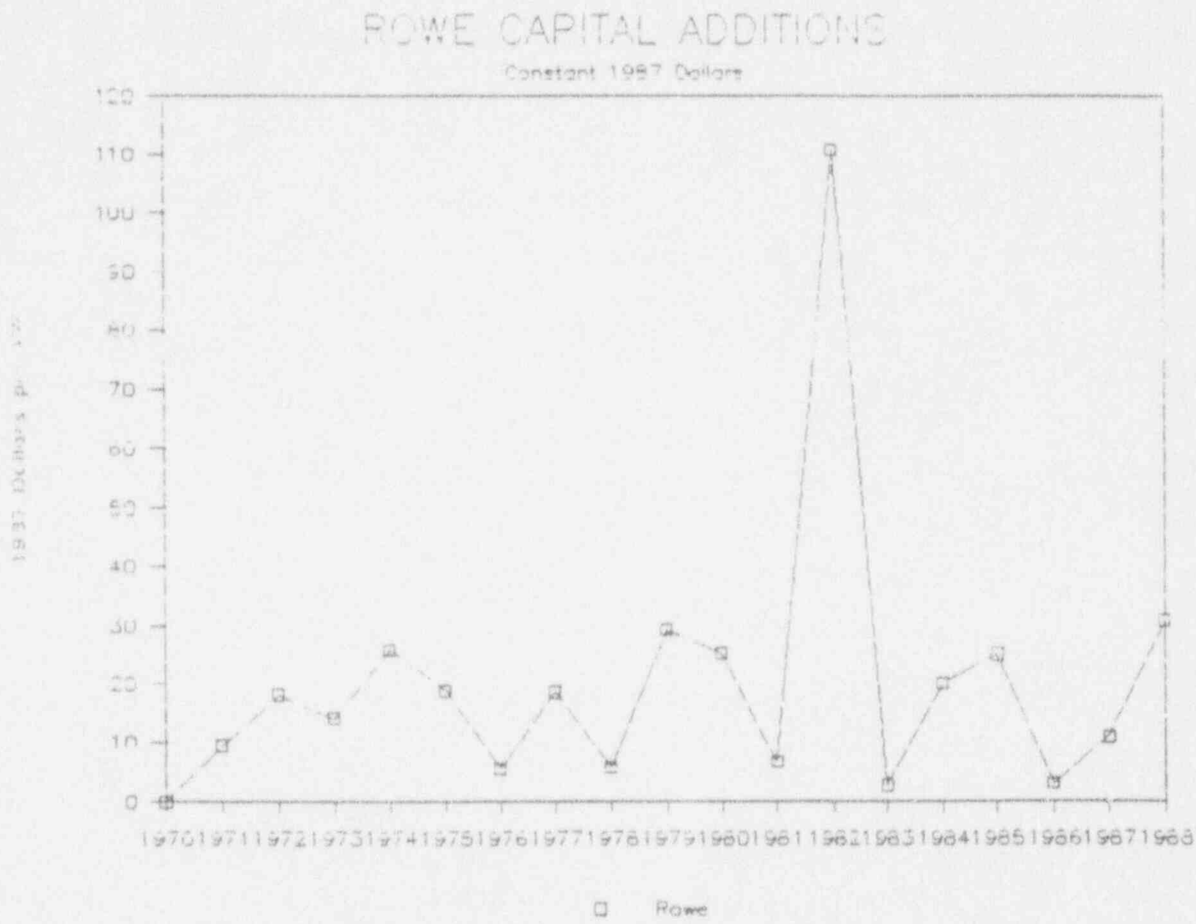
$2.5 million. Rowe's average annual capital additions between 1980 and 1986 of $27.6 per kW in constant 1987 dollars is close to the national average during that period of $29.6 per kW.[10]

With relatively large year-to-year variability in Rowe additions, there is no clear evidence that the plant has experienced a rising trend in capital additions (Figure 1). Such a trend is clearly visible in national average data, however, with capital additions costs growing at an average of about $1.7 per kW, or 16.3 percent per year since 1970, after adjusting for inflation. Figures 2 and 3 illustrate this trend, with best-fitting linear and exponential trend lines.

The primary factor underlying increasing total costs at Yankee Rowe has been the rising cost of routine operation and maintenance. Even after adjusting for inflation, routine O&M costs at Rowe have increased dramatically to levels well above the national average. Average Rowe O&M from 1980 to 1986 were $162.4 per kW in 1987 dollars, more than three times the national average of $53.2 per kW (Figure 4). Recent figures compiled by the Energy Systems Research Group indicate that Yankee Rowe has had the second highest O&M costs per kilowatt of any U.S. nuclear reactor over the last four years.[11]

Both Yankee Rowe and national historical O&M trends are characterized more closely by exponential trend lines than linear (Figures 5, 6, 7, 8).

Figure 1



Source: FERC Form 1

Figure 2

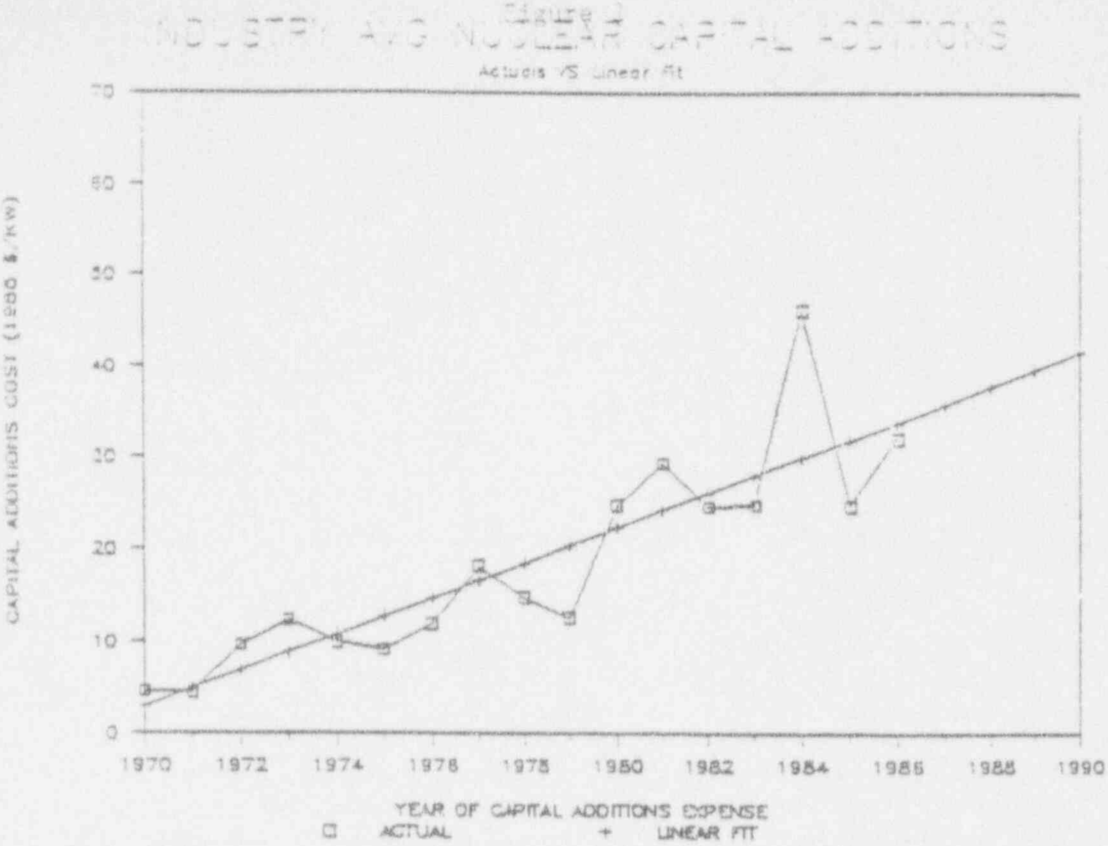
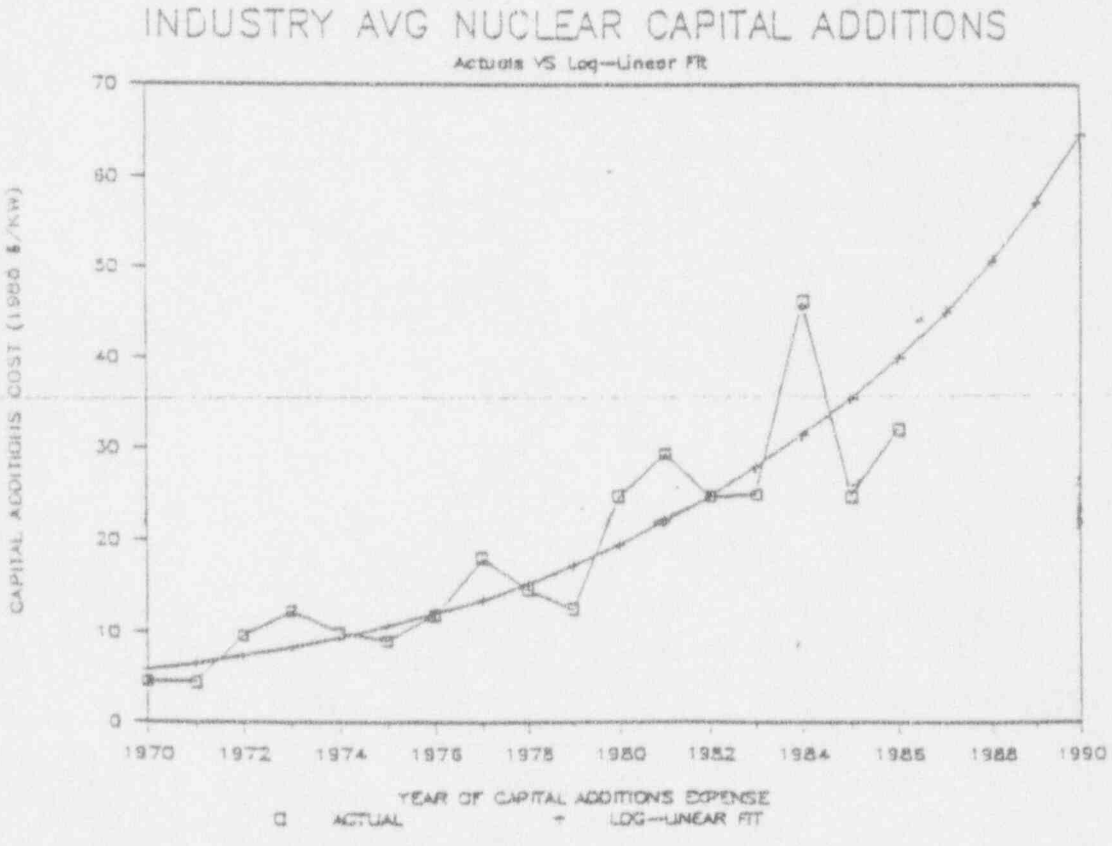
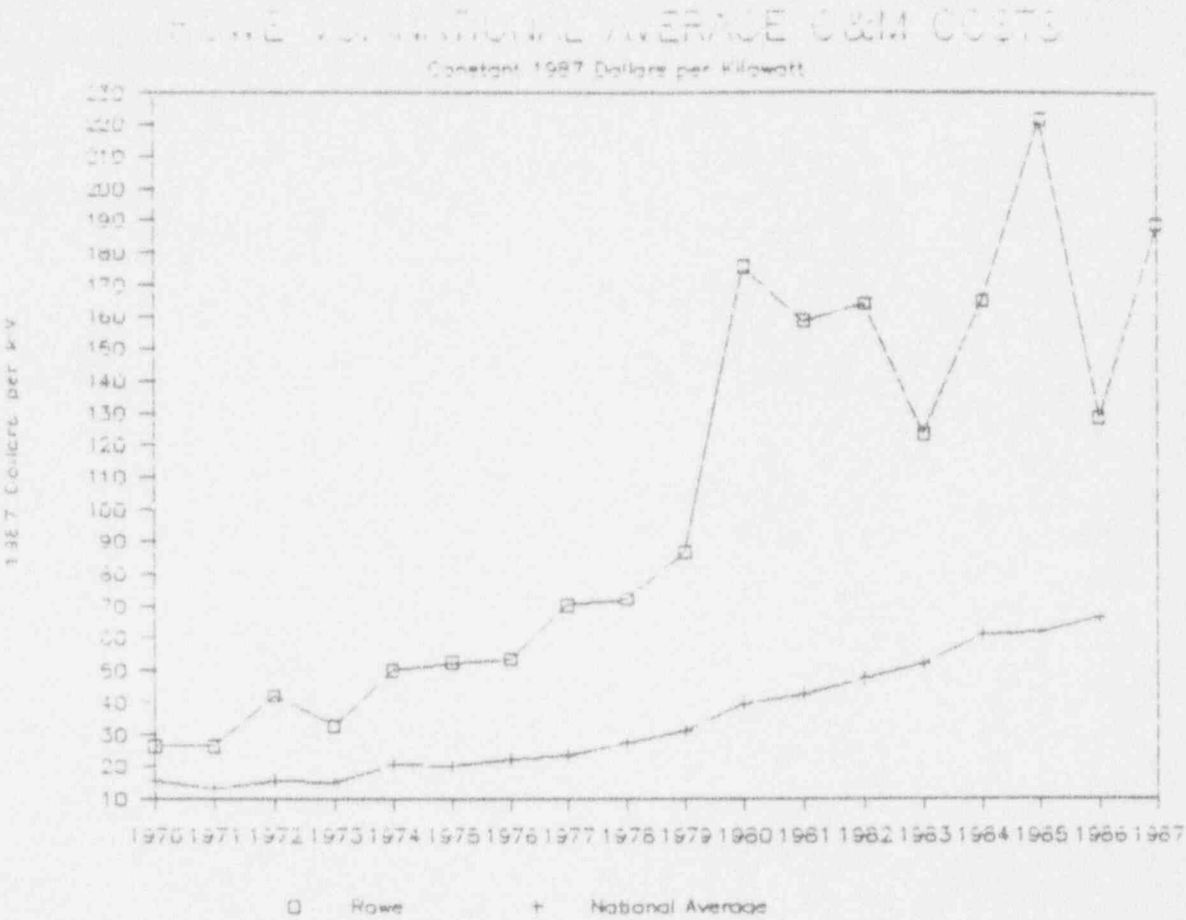


Figure 3



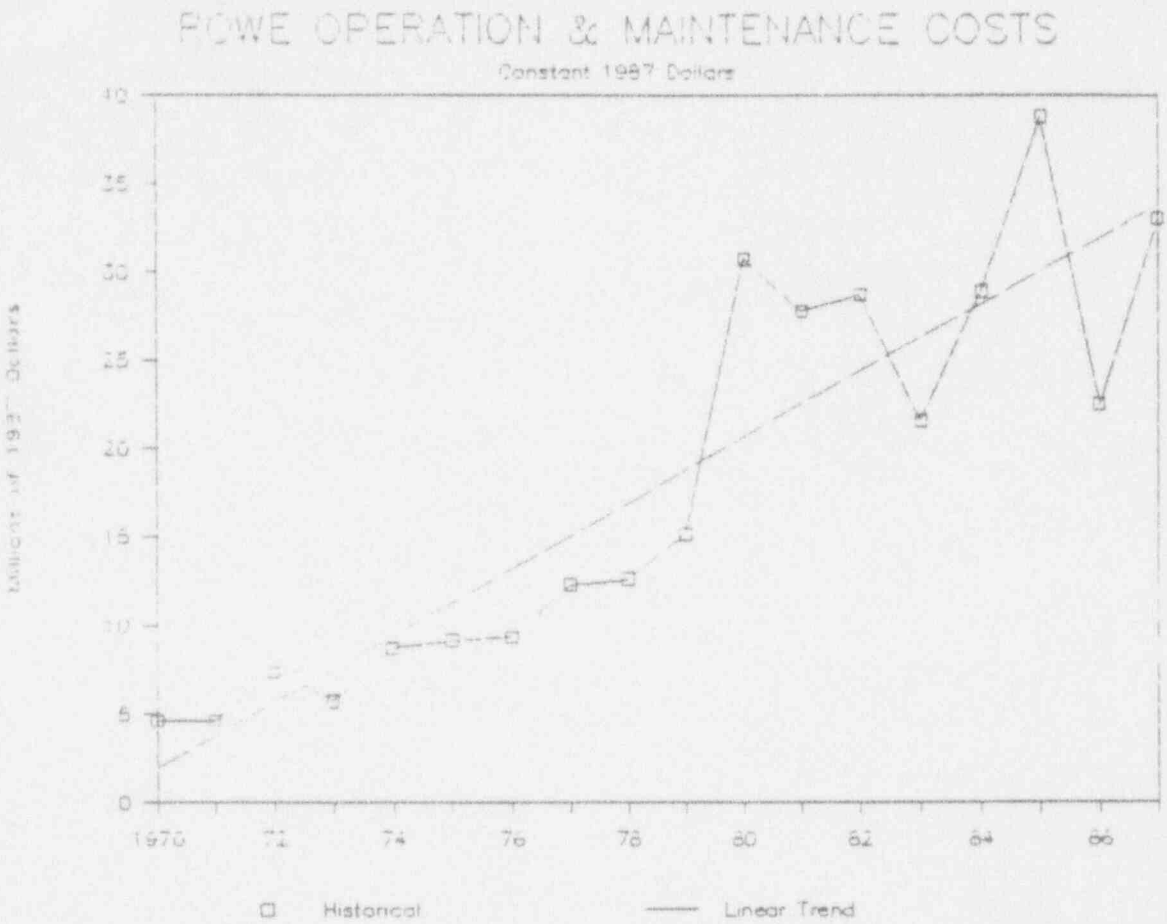
Source: Energy Systems Research Group

Figure



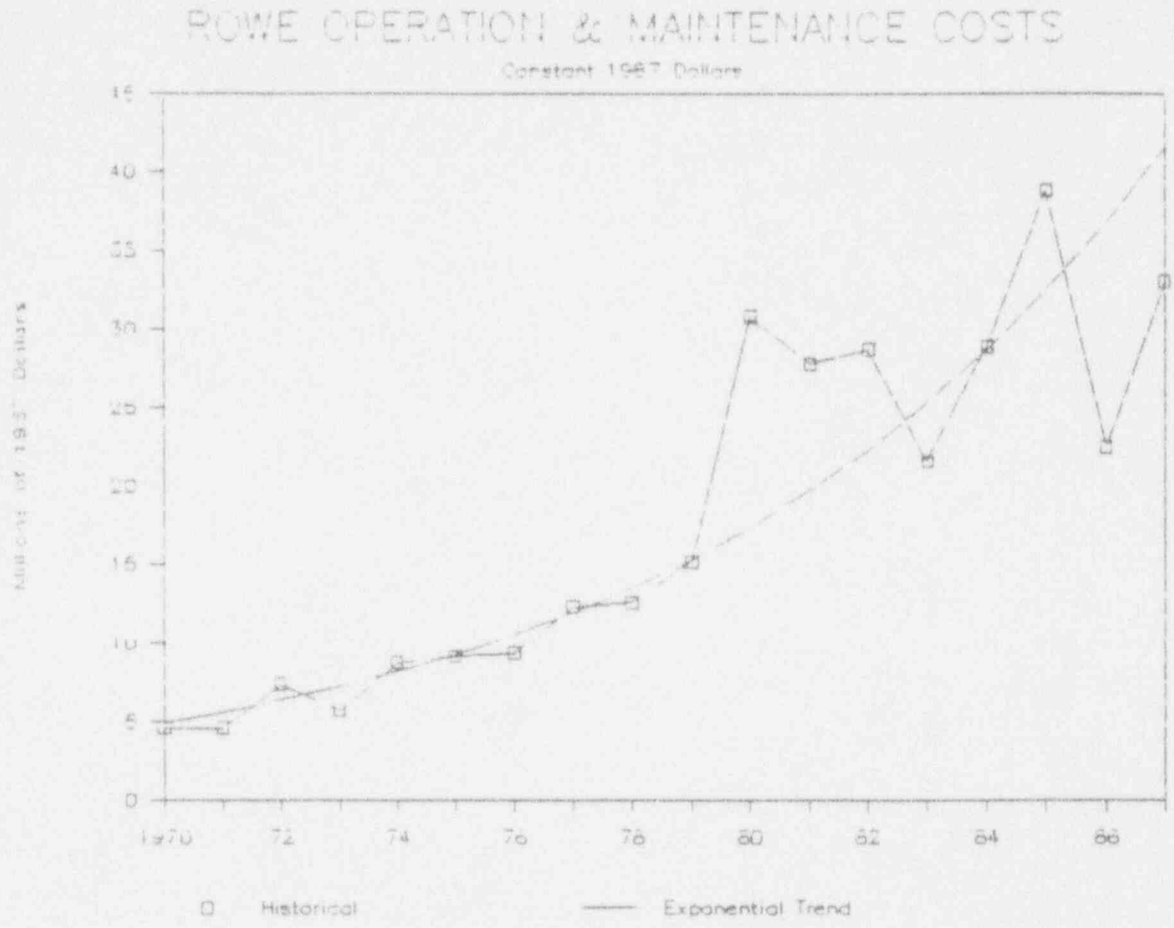
Sources: FERC Form 1
Energy Systems Research Group

Figure 5



Source: FERC Form 1

Figure 6



Source: FERC Form 1

Figure 7

INDUSTRY AVERAGE NUCLEAR O&M COSTS

Actuals VS Linear Fit

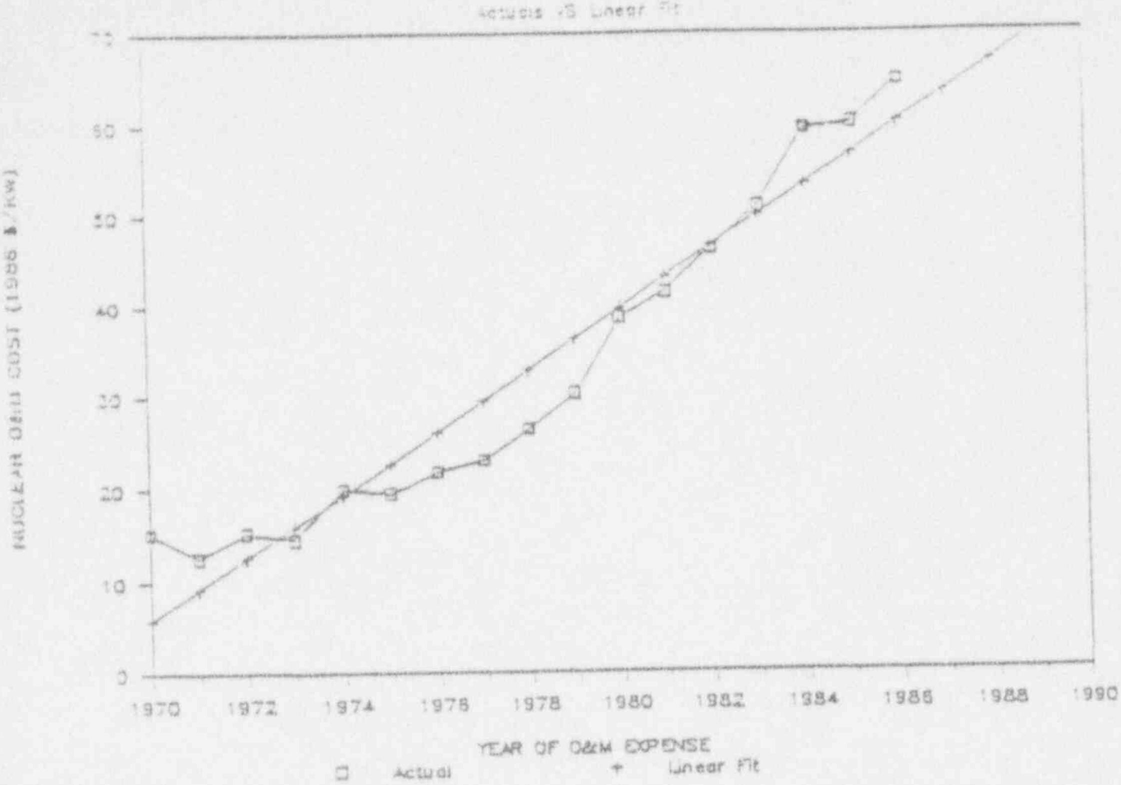
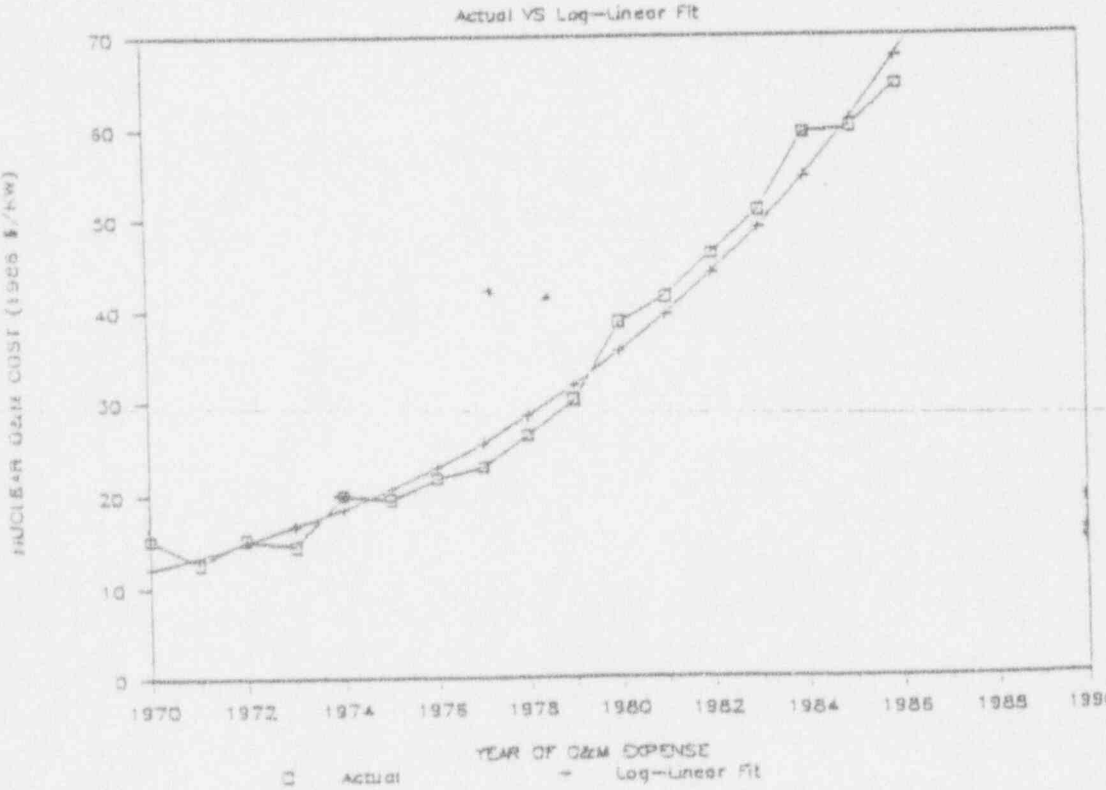


Figure 8

INDUSTRY AVERAGE NUCLEAR O&M COSTS

Actual VS Log-Linear Fit



Source: Energy Systems Research Group

4. Yankee Rowe Continued Operation Cost Projections

A. Effects of general nuclear cost trends.

A number of analysts have attributed rapidly escalating O&M costs at nuclear plants nationally largely to the effects of aging, as well as to increasing safety regulations. Other factors affecting capital additions and O&M costs include location, with Northeast plants experiencing higher costs; size, with larger and multiple-unit plants having lower costs per kilowatt; manufacturer, with General Electric plants increasing faster than others; salt-water cooling; and the amount of nuclear experience of a utility. After the 1979 Three Mile Island accident, O&M costs also tended to increase for all plants.[12]

The aging, location, and especially the size factor have all likely tended to raise Rowe O&M costs with respect to the national average. As the second smallest nuclear plant in the U.S., Rowe faces many of the same regulatory requirements as larger plants, but is unable to achieve economies of scale. Additionally, because Rowe is so old, and has an uncertain life span, its owners have probably chosen to treat some recent repair costs as direct expenses, to be immediately charged to customers, rather than capital additions which are added to the utility's rate base and recovered, with a profit, over the plant's remaining life.

It is highly likely that real capital additions and operation and maintenance costs will continue to increase in the future, as the factors underlying the historical trends still persist. Major driving forces include the persistence of unresolved nuclear safety issues, ongoing technical problems that are discovered as the industry gains more operating experience, and the aging of reactor components.

The Nuclear Regulatory Commission maintains a list of over 100 unresolved safety issues which are generic to nuclear power reactors. As these issues are resolved, they frequently require significant new expenses to implement them. In recent years, new issues have been added to the list about as fast as old ones have been resolved.[13]

There is also persistent evidence that nuclear technology has not yet "matured," and that reactor operation will continue to be plagued with safety-related and non-safety related problems that will require new O&M and capital additions expenditures. The number of Licensee Event Reports (LERs) -- which document mishaps at nuclear plants -- has steadily increased.[14] Nuclear plant capacity factors have failed to increase as the nuclear industry predicted they would as plants matured.

The need to replace worn plant components and systems has greatly outpaced industry expectations. A 1984 NRC staff report identified 5,893 events in safety-related systems occurring between 1969 and 1982 (17 percent of all LERs) as age-related. Additional aging problems have occurred in non-safety-related systems. Aging problems have been caused by wear and tear, corrosion, internal and external radiation contamination, contact, vibration, stress corrosion, erosion, and a category of miscellaneous problems.[15] Recently, Nuclear Regulatory Commission (NRC) member Kenneth Roberts referred to the aging problem at nuclear plants as "a loaded gun."

A March, 1988 study by the U.S. Department of Energy did not find evidence of an aging effect on O&M costs (although it did confirm such an effect on capital additions salt-water-cooled Boiling Water Reactors like Pilgrim). The DOE attributed the bulk of rising O&M costs to increased regulation. The average age of plants in the DOE study was only eight years, however, so it is possible that there was simply not enough data for the aging effect to appear. The DOE report did find that O&M costs were rising rapidly and concluded that:

> If operating costs continue to escalate, it may become economical to close some of the older plants, and thus the assumption of a 40-year operating life may be optimistic.[16]

There is no commercial nuclear plant experience with reactors older than Yankee Rowe (Table 3). A significant number of reactors have been retired with considerably fewer years of operation (Table 4).

Table 3. OLDEST U.S. OPERATING NUCLEAR REACTORS

Plant	Location	Initial Operation	Age	Capacity (MW)
Yankee	Rowe, MA	1960	28	185
Big Rock Point	Charlevoix, MI	1962	26	75
San Onofre 1	San Clemente, CA	1967	21	450
Haddam Neck	Haddam Neck, CT	1967	21	600
Oyster Creek	Forked River, NJ	1969	19	550
Nine Mile Point 1	Scriba, NY	1969	19	642
Ginna	Ontario, NY	1969	19	517
Dresden 2	Morris, IL	1970	18	794
Robinson 2	Hartsville, SC	1970	18	769
Point Beach 1	Two Creeks, WI	1970	18	485
Millstone 1	Waterford, CT	1970	18	660

Table 4. RETIRED U.S. REACTORS

Plant	Initial Operation	Retirement	Age	Capacity
Three Mile Island 2	1978	1979	1	906
Pathfinder	1966	1967	1	66
Hallam	1963	1964	1	256
Piqua	1963	1966	2	45
CVTR	1963	1967	3	65
Bonus	1964	1968	4	50
Elk River	1963	1968	4	22
Fermi 1	1966	1972	6	61
Peach Bottom 1	1967	1974	8	40
Indian Point 1	1962	1974	12	265
Humboldt Bay	1963	1976	13	65
Dresden 1	1960	1978	19	207
LaCrosse	1968	1987	19	50
Shippingport	1957	1982	25	25

Source: Critical Mass Energy Project; Nuclear Regulatory Commission

The utility industry's Electric Power Research Institute (EPRI) has implemented a research and development program in order to address nuclear O&M cost escalation and to attempt to increase capacity factors. It is significant, however, that the goal of EPRI's program is to reduce O&M escalation from its historical 20 percent per year rate (in nominal dollars) to 10 percent per year -- approximately two times the rate of inflation.[18]

B. Methodology

In order to project future Yankee Rowe costs, this report uses the same basic methods as MASSPIRG's November, 1987, report analyzing the economics of the Pilgrim nuclear plant,[19] and a report on Pilgrim to the Executive Office of Energy Resources.[20] Both the MASSPIRG and EOER Pilgrim studies were based on a model used by Boston Edison in its Pilgrim economic analysis presented to the state energy office.[21] Edison assumptions about capital additions, O&M costs and capacity factor were modified, however, to reflect actual historical experience at Pilgrim and other nuclear plants.

For this study, assumptions for each major cost factor were also derived from the historical experience of the Yankee Rowe plant. Data was obtained from forms filed by Yankee Atomic Co. with the Federal Energy Regulatory Commission (FERC Form 1). FERC forms back to 1981 are on file at the Massachusetts Department of Public Utilities. Rowe capital additions and O&M costs from 1970 through 1980 were obtained from the Energy Systems Research Group, a Boston-based consulting firm. General cost escalation assumptions for translating constant dollars into nominal dollars were taken from NEPOOL's 1988 Generation Task Force Assumption Book.

Two scenarios were created, to represent plausible "high" and "low" range assumptions for capital additions and operation and maintenance cost assumptions. Neither set of assumptions was chosen to represent the extremes of possible future Rowe costs or performance, but were selected to represent reasonable but conservative estimates based on historic cost trends at Rowe. They were chosen to be as favorable to continued Rowe operation as possible.

C. Capital additions

In the low case, annual capital additions are assumed to average $2.4 million through 1995, then decline by 20 percent per year until the plant is retired in the year 2000. The $2.4 million figure represents average Rowe additions from 1970 - 1987, excluding 1982's exceptional costs. In effect, this scenario assumes that the 1982 major repair was a one-time event. The assumption of a decline over the last five years of the plant's life is taken from Boston Edison's projections of Pilgrim capital additions.

In the high case, it is assumed that capital additions start with the $3.5 million per year average of all years from 1970 - 1987, and increase by $0.275 million per year, based on the average annual national increase per kW between 1980 - 1986. This case thus essentially assumes that new regulations and age will require increasing capital additions, but at a declining rate of increase, and that at least one major repair analogous to that needed in 1982 will be required in the remaining 11 years the plant is licensed to operate.

After the plant is fully depreciated in 1990, capital additions are essentially treated as annual expenses. The company is assumed to continue earning an 11.3 percent overall return on remaining investment in nuclear fuel, based on a FERC order from September, 1987.

D. Operation and Maintenance Costs

Inflation-adjusted O&M costs at Rowe are assumed to increase linearly according to historic cost trends. In the high case, it is assumed that real O&M costs continue to increase by the same average dollar amount as they have from 1970 to 1987. A linear regression analysis was used to calculate the straight line that best fit historical Rowe O&M costs (Figure 9).

Beginning in 1980, Rowe O&M costs increased dramatically in overall amount and in variability. Some nuclear analysts have found an increase in O&M costs for nuclear plants nationally following the 1979 Three Mile Island (TMI) accident. The higher costs presumably reflect regulatory changes that were adopted in response to that accident. Because of the variability in Rowe O&M costs after 1979, it is difficult to determine if a new trend was also established. For a low scenario, this report assumes that there was a large O&M increase in 1980, accompanied by smaller annual increases in O&M following that date. The trend line was calculated by regression analysis on a 3-year rolling average of Rowe O&M costs from 1980 through 1987.

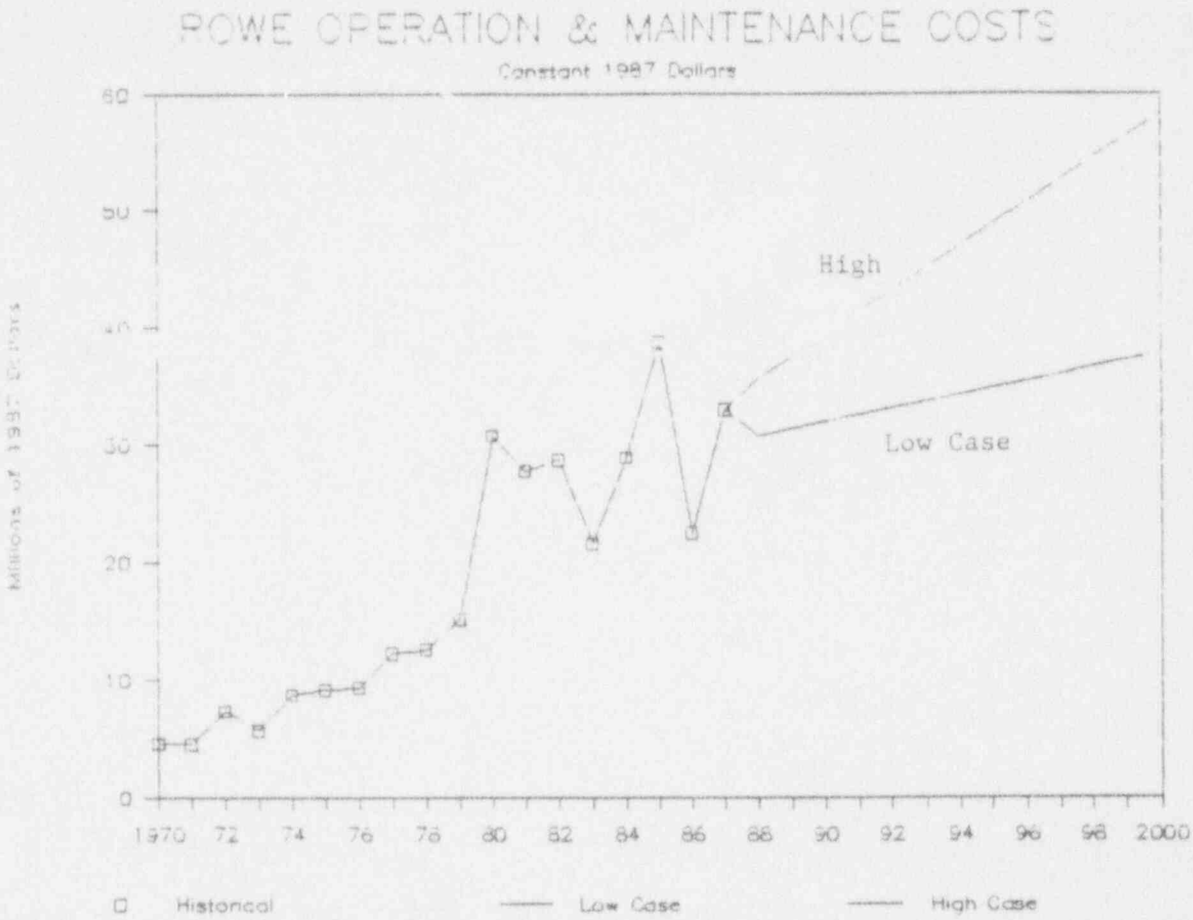
Both cases presented here are conservative in assuming linear increases -- i.e., a constant dollar amount per year -- rather than exponential increases of a constant percent per year. Overhead costs are assumed to be 15.2 percent of O&M costs each year, based on the average percentage of overhead expenses for the years 1981 through 1987.

It is noteworthy that Boston Edison recently used a similar methodology for projecting O&M costs in a study of the costs and benefits of extending the lives of its fossil fuel plants. Edison projected linear constant dollar O&M increases to account for plant aging effects, and assumed overhead costs of an additional 40 percent, well above the rates assumed here (Figure 10).[22]

E. Capacity Factor

Both cases assumed a 70.8 percent capacity factor, equal to Rowe's average for 1975 through 1987. Most analysts assume that nuclear capacity factors reach a plateau after several years, and then decline in the later years of a plant's life.[23] Assuming that Rowe will continue at the same capacity factor throughout its entire life thus creates a bias in its favor.

Figure 9



Source: FERC Form 1
MASSPIRG

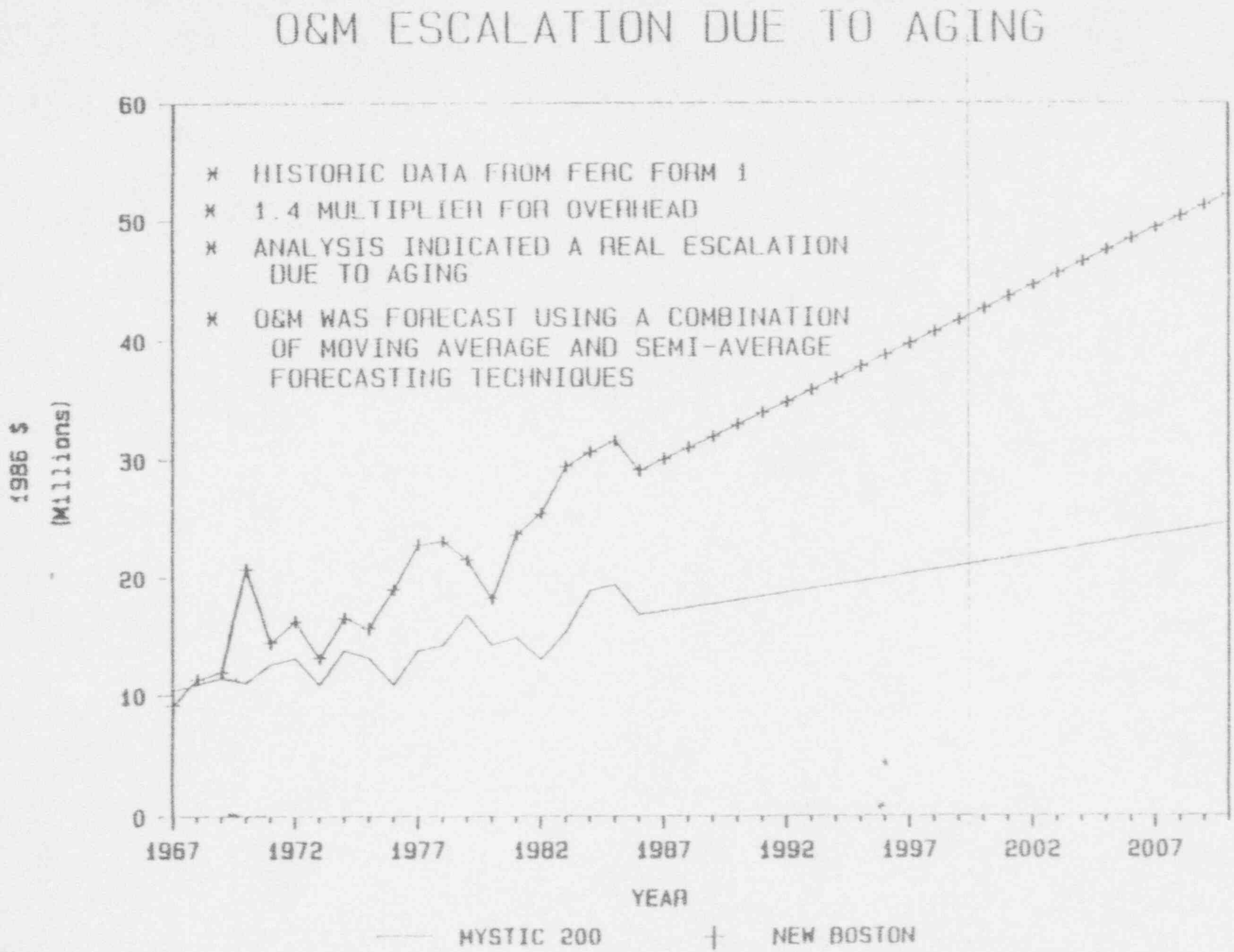

O&M ESCALATION DUE TO AGING
* HISTORIC DATA FROM FERC FORM 1
* 1.4 MULTIPLIER FOR OVERHEAD
* ANALYSIS INDICATED A REAL ESCALATION DUE TO AGING
* O&M WAS FORECAST USING A COMBINATION OF MOVING AVERAGE AND SEMI-AVERAGE FORECASTING TECHNIQUES
1986 $ (Millions)
60
50
40
30
20
10
0
1967
1972
1977
1982
1987
1992
1997
2002
2007
YEAR
MYSTIC 200
NEW BOSTON

FIGURE C-1

5. Yankee Rowe Retirement Cost Projections

A. Replacement power

The primary cost of retiring Rowe is the expense of replacing its electricity output. For replacement power costs, the study uses the "avoided costs" filed by Rowe's owners with the Massachusetts Department of Public Utilities, weighted by their shares of the Rowe plant. Avoided costs represent the cost of operating and building additional power plants that utilities can avoid incurring if they purchase power from an independent cogeneration facility or small power producer. In the short run, avoided costs generally represent the operating and fuel costs of reserve power plants. At the point where each utility needs new power plant capacity, avoided costs also include capacity charges.

The avoided cost projections were taken from a May, 1988, study done by the Nova Scotia Power Corporation on the feasibility of a proposed coal plant with undersea transmission cable to Boston Edison, known as the "Bluenose Project."[24] (Table 5). In order to be as favorable to Rowe as possible, capacity charges were then moved up one year. That is, it is assumed that without Rowe, each utility would need new power plant capacity to meet its obligation to NEPOOL one year earlier than if Rowe were available. This is also an assumption favorable to Rowe, since the nuclear plant represents no more than one percent of each utility's capacity, and each company's demand is growing at a faster rate than one percent per year. Having Rowe available would thus not really forestall the need for new capacity by a full year.

Moreover, utilities' published avoided costs really represent a reasonable upper limit on future replacement power costs, because of the large number of cogeneration and renewable energy small power projects that have submitted bids below the utilities avoided costs. Boston Edison received

TABLE 5

BLUENOSE PROJECT DELIVERED UNIT COST TO PLYMOUTH
WITH MASSACHUSETTS UTILITY AVOIDED COSTS[1]

(U.S. .,

Year	Total Delivered Unit Cost Cts/kW.h	(2) Mass. EL Cts/kW.h	(3) Latest BECO CTS/kW.h	(4) WMECo Cts/kW.h	(5) FG&ECo Cts/kW.h	(6) EUA Cts/kW.h	(7) CELCO Cts/kW.h	(8) COMELEC Cts/kW.h
1987		3.09		2.40	3.46	3.01	3.37	3.38
1988		3.05	3.19	2.60	3.70	2.75	3.73	3.43
1989		3.17	2.81	2.80	5.34	2.91	3.71	3.46
1990		3.20	3.08	2.70	5.65	2.70	3.71	3.72
1991		3.28	2.96	3.20	6.18	2.89	4.50	4.57
1992		3.70	2.96	3.40	6.76	3.32	4.31	5.00
1993		4.06	3.75	3.90	7.41	3.75	4.92	5.49
1994		4.43	3.76	4.40	8.12	5.06	6.87	6.02
1995		7.65	3.94	4.90	8.90	5.57	7.61	6.65
1996		8.08	4.84	5.60	9.76	6.08	5.26	7.37
1997	12.04	8.56	5.29	6.60	10.72	6.82	5.45	8.21
1998	12.07	9.04	5.83	7.80	11.78	7.23	6.00	9.21
1999	12.12	9.52	7.12	9.10	12.94	8.40	8.74	10.39
2000	12.17	10.01	8.70	11.00	14.23	8.66	10.76	11.74
2001	12.24	10.57	8.93	12.00	15.66	9.70	14.53	13.14
2002	12.32	11.16	10.28	13.50	17.24	10.71	17.03	14.59
2003	12.40	11.70	12.01	14.60	18.99	12.23	18.63	16.07
2004	12.51	12.28	11.68	16.10	20.93	13.38	19.03	17.65
2005	12.62	12.92	15.35	18.00	23.07	14.82	18.18	19.45
2006	12.75	13.57	16.48	19.70	25.45	16.41	25.52	21.19
2007	12.89	14.24	16.56	19.10	28.09	16.66		
2008	13.05	15.00	18.17	21.80	31.01			
2009	13.22	15.80	19.10	23.00	34.25			
2010	13.41	16.63	19.83	25.00	37.84			
2011	13.61	17.52	22.15		41.83			
2012	13.83	18.46			46.26			
2013	14.07	19.44						
2014	14.33	20.48						
2015	14.61	21.58						
2016	14.92							

Notes: (1) Utility avoided costs are available at the Massachusetts D.P.U.
(2) Mass. Electric Co.
(3) Boston Edison Company
(4) Western Massachusetts Electric Company
(5) Fitchburg Gas and Electric Company
(6) Eastern Utilities Associates
(7) Cambridge Electric Light Company
(8) Commonwealth Electric Company

offers of 1,848 MW of capacity at prices averaging 15 - 30 percent below its 1987 avoided cost projections, and has signed contracts for 344 MW.[25] New England Power, the generating company which supplies Massachusetts Electric, has received bids from 4,729 MW of cogeneration and small power capacity at prices below its avoided costs.[26] While not all of the cogeneration or small power projects may prove to be viable or environmentally acceptable, the 174 MW Yankee Rowe plant could easily be replaced from this abundance of independently produced power.

Investments in energy efficiency improvements represent an even less expensive and more environmentally sound source of potential replacement power for Rowe. A 1987 study by the New England Energy Policy Council found that New England could reduce the peak demand for electricity forecast for the year 2005 by over 11,000 MW with energy efficiency technologies that are commercially available today. New technologies for lighting, refrigeration, industrial motors and other uses of electricity often cost less than two cents for each kilowatt hour saved, far less than the cost of operating Rowe or the replacement power sources assumed for the purposes of this report.[27]

B. Decommissioning and other shutdown costs

Yankee Atomic estimates that decommissioning Rowe will cost $68 million (in 1984 dollars), which it expects to pay for by collecting $5.7 million per year through 1997 in rates. The company had accumulated $26.3 million in a decommissioning trust fund by the end of 1987.[28]

Decommissioning costs will have to be paid whether Rowe is closed by ballot initiative in 1989 or retired sometime later. In either case, Yankee Atomic is likely to adopt the policy being implemented at other retired reactors, and wait as many as 20 to 30 years before undertaking actual decommissioning, in order to let high radiation levels decay. It is therefore assumed that decommissioning costs will be the same in both the Rowe operation and Rowe retirement cases.

In its Pilgrim analysis presented to the EOER, Boston Edison projected O&M costs during a six year period following shutdown equal to 40 percent of the prior year O&M during the first year of shutdown, and 20 percent in the five subsequent years. It is likely that the same costs would be incurred whether a nuclear plant is shut down immediately or at the end of its normal expected life. Nevertheless, to be conservative the same ratio of shutdown O&M costs Edison assumes for Pilgrim is applied to Yankee Rowe here.

State and local taxes are assumed to be paid at the same rate of 1.9 percent of the utility rate base that they are in the Rowe operation scenario, although the rate base is, of course, smaller due to avoiding capital additions and additional nuclear fuel investments.

C. Compensation

This study assumes, for the purposes of analysis, that Yankee Atomic is fully compensated for its unrecovered investment in Rowe. The company is assumed to earn the same profit on its investment if the plant is retired as it would have earned if he plant had operated.

Such compensation is highly likely to be paid in rates. The utility owners who also contract for power from Rowe are obligated to pay for all expenses, including return on investment, through June 1991, whether the plant operates or not.[29] The Department of Public Utilities and the Federal Energy Regulatory Commission, will then have to decide how much, if any, of the unrecovered investment in the plant is eligible for recovery and/or earning a return from ratepayers based on the prudence and/or economic usefulness of the investment.

6. Economic Comparison of Rowe Operation vs. Retirement

Under high case assumptions, continuing to operate Rowe through the year 2000 would cost $725 million (net present value), $357 million more than replacement power costs at $368 million. When decommissioning, shutdown costs and compensation are added to retirement costs, ratepayers would realize a net savings of $267 million if Rowe is retired now. (Table 6).

Under low case assumptions, continuing to operate Rowe would cost a total of $564 million, $196 million more than the cost of replacement power. After adding decommissioning, shutdown and compensation to the cost of retirement, ratepayers would save a total of $114 million if the plant were retired now (Table 7).

In addition to the two scenarios which are considered to represent conservative but reasonable projections of future Rowe costs, the study also examined what hypothetical assumptions would be necessary to make Rowe break even with utility projections of replacement power costs. It was found that even if there were no real increase in capital additions and operating and maintenance costs (from low level starting assumptions), Rowe would have to improve its capacity factor from its historical 71 percent to an 83 percent level in order to break even in net present value.

To be as favorable to Rowe as possible, all of the above cases used utility avoided cost assumptions for replacement power costs, while even less expensive alternatives -- such as cogeneration, renewable small power plants, and energy efficiency investments -- would certainly be available and preferable to conventional power plants from both an economic and environmental perspective.

TABLE 6

YANKEE ROWE OPERATION VS. RETIREMENT

HIGH CASE

YANKEE ROWE OPERATION														RETIREMENT					NET SAVINGS		SAVINGS	
[illegible] Years	Ann. Depreciation	Acc. Depreciation	Net Plant Year-End	Nuclear Fuel	Avg. Rate Base	Return on Rate Base	Income Tax	Local Tax	Decommissioning	Fuel	O&M	Overhead	Annual Rowe Costs	Decommissioning	Shutdown Costs	Compensation	Replacement Power	Total Retirement	Annual Savings	Cumulative Savings Net Present Value		Cumulative Savings Net Present Value
41	8	82	10	23	75	4	1	1	6	12	41	6	77	6	19	10	22	61	16	16	1	11
48	11	[illegible]	[illegible]	23	23	[illegible]	[illegible]	1	6	12	45	7	86	6	11	11	[illegible]	[illegible]	[illegible]	40	2	28
[illegible]	8	[illegible]	[illegible]	22	22	[illegible]	[illegible]	1	6	13	49	7	84	6	10	8	75	81	24	65	[illegible]	43
[illegible]	7	[illegible]	[illegible]	23	23	[illegible]	1	1	6	14	54	8	91	6	10	[illegible]	78	[illegible]	23	91	[illegible]	55
112	6	104	[illegible]	20	20	[illegible]	1	1	6	14	60	9	100	6	10	[illegible]	44	59	41	116	[illegible]	[illegible]
[illegible]	[illegible]	115	3	31	31	[illegible]	1	1	6	15	66	10	108	6	10	4	60	74	35	138	[illegible]	80
[illegible]	[illegible]	127	4	33	33	[illegible]	1	1	6	16	73	11	118	6	[illegible]	4	67	71	47	159	7	87
[illegible]	8	131	4	36	36	4	1	1	6	17	81	12	130	6	0	4	71	75	55	184	[illegible]	98
144	9	139	5	27	27	3	1	1	6	18	90	14	140	6	0	4	79	82	58	208	[illegible]	106
155	10	149	5	18	18	2	1	0	0	20	99	15	146	0	0	3	87	91	56	229	1	112
166	11	160	6	9	9	1	0	0	0	21	109	17	159	0	0	3	98	101	58	249	[illegible]	114
179	12	173	6	[illegible]	[illegible]	0	0	0	0	22	120	18	173	0	0	3	111	113	59	257	[illegible]	114
[illegible]						31	3	6	52	195	837	135	1412	52	69	61	755	935	527			
[illegible]						19	5	4	33	112	443	67	725	33	51	[illegible]	368	453	267			

TABLE 7

YANKEE ROWE OPERATION VS. RETIREMENT

LOW CASE

	YANKEE ROWE OPERATION															RETIREMENT					NET SAVINGS	
Year	Capital Add	Util. Plant Year End	Ann. Depreciation	Acc. Depreciation	Net Plant Year-End	Nuclear Fuel	Avg. Rate Base	Return on Rate Base	Income Tax	Local Tax	Decommissioning	Fuel	O&M	Overhead	Annual Rowe Costs	Decommissioning	Shutdown Costs	Compensation	Replacement Power	Total Retirement	Annual Savings	Cumulative Savings Net Present Value
ns of dollars																						
1989	7	90	7	81	9	22	23	4	1	1	6	12	34	5	69	6	16	10	32	58	11	11
1990	7	93	10	91	2	22	28	3	1	1	6	12	36	6	74	6	8	11	33	52	22	33
1991	7	96	7	94	2	22	23	3	1	1	6	13	39	6	76	6	8	5	35	49	21	47
1992	7	99	7	97	2	23	23	3	1	1	6	14	42	6	75	6	8	5	38	51	22	59
1993	7	102	7	100	2	21	21	3	1	1	6	14	45	7	80	6	8	5	44	57	22	77
1994	3	105	3	104	2	21	21	3	1	1	5	15	48	7	85	6	3	4	60	72	12	80
1995	4	109	4	107	2	23	23	3	1	1	5	16	52	8	91	6	0	4	67	71	19	89
1996	3	112	3	111	2	26	26	4	1	1	5	17	57	9	97	6	0	4	71	75	22	98
1997	3	115	3	113	1	27	27	3	1	1	5	18	61	9	102	6	0	4	79	82	20	102
1998	2	117	2	116	1	18	18	2	1	0	0	20	67	10	102	0	0	3	87	91	11	112
1999	2	119	2	118	1	9	9	1	0	0	0	21	72	11	107	0	0	3	98	101	7	114
2000	2	121	2	120	1	0	0	0	0	0	0	22	78	12	114	0	0	3	111	113	1	114
TOTAL $			46					31	6	6	52	195	672	96	1065	52	59	61	755	874	191	
NET PRESENT VALUE			23					19	5	3	27	102	324	49	564	27	42	39	368	450	114	

NOTES

[1]Yankee Atomic Co., The Yankee Story, 8th Edition

[2]Atomic Industrial Forum, "Historical Profile of Nuclear Power Development," January 1, 1987.

[3]Annual generation figures compiled by Energy Systems Research Group, Boston, Mass., from NRC Grey Book.

[4]New England Power Pool, "NEPOOL Forecast Report of Capacity, Energy Loads and Transmission 1988-2003," p. 1, based on Yankee Rowe 174 MW capacity and New England capacity of 22697 MW.

[5]ibid.

[6]See, e.g., Alan Nogee, Gambling for Gigabucks: Excess Capacity in the Electric Utility Industry, Environmental Action Foundation, October, 1986.

[7]Janet Besser, Executive Office of Energy Resources, Response to Pat Granahan Information Request #2, July 15, 1988.

[8] Yankee Atomic Co., The Yankee Story, 8th Edition

[9]All Yankee Rowe statistics are from FERC Form 1, unless otherwise indicated.

[10] National costs from Stephen Bernow, Energy Systems Research Group, "Excess Capacity and Cost Benefit Analysis of Vogtle Electric Generating Station," on behalf of the Georgia Office of Consumers' Utility Counsel, before the Georgia Public Service Commission, Docket No. 3673-U, August, 1987.

[11]Bruce Biewald, personal communication, October 26, 1988.

[12]See Bernow, op. cit.; also, Charles Komanoff, "Statistical Analysis of Nuclear Industry O&M and Capital Additions Costs and Performance," March 24, 1988; Energy Information Administration (EIA), U.S. Department of Energy, An Analysis of Nuclear Power Plant Operating Costs, DOE/EIA-0511, Washington, D.C., March, 1988.

[13]"Efforts to Ensure Nuclear Power Plant Safety Can Be Strengthened," General Accounting Office, GAO/RCED-87-141, August, 1987.

[14]Joshua Gordon, 1986 Nuclear Power Safety Report, Public Citizen, Washington, D.C., September, 1987.

[15]"Survey of Operating Experience from LERs to Identify Aging Trends, Status Report," Nuclear Regulatory Commission, NUREG/CR-3543, January 1984.

[16] EIA, op. cit., Note 12.

[17]Gordon, op. cit., Note 14.

[18] Research & Development Program Plan 1987 - 1989, Electric Power Research Institute (EPRI), January, 1987, p. 49.

[19] Alan Nogee, Nuclear Lemon: Ratepayer Savings From Retiring the Pilgrim Nuclear Power Plant, Massachusetts Public Interest Research Group, Boston, MA, November, 1987.

[20] Paul Chernick, Candace Wills, and Michael Meyer, "Application of the DPU's Used-and-Useful Standard to Pilgrim 1," Report to the Massachusetts Executive Office of Energy Resources, Revised October, 1987.

[21] Carl Gustin, Letter to Sharon Pollard, Secretary of Energy Resources, Commonwealth of Massachusetts, June 8, 1987.

[22] Boston Edison Co., Life Extension and Performance Improvement Group, "Life Extension, Performance Improvement, Plant Uprate, A Generation Option," October, 1986.

[23] See Bernow, Komanoff, Note 10.

[24] Nova Scotia Power Corporation, "Bluenose Project: Nova Scotia to New England HVDC Cable Project," May, 1988. Energy Facilities Siting Council Docket No. 88-12, Boston Edison Co. Long-Range Forecast, MASSPIRG Exhibit #1.

[25] Energy Facilities Siting Council Docket No. 88-12, Boston Edison Co. Long-Range Forecast, Transcript 1, p. 48, Subject to Check 2, September 20, 1988.

[26] "New England Power Company Receives Bids for Independent Power Projects," New England Power News, July 19, 1988.

[27] Power to Spare: A Plan for Increasing New England's Competitiveness Through Energy Efficiency, New England Energy Policy Council, July 1987.

[28] Yankee Atomic Co., 1987 Annual Report.

[29] ibid.