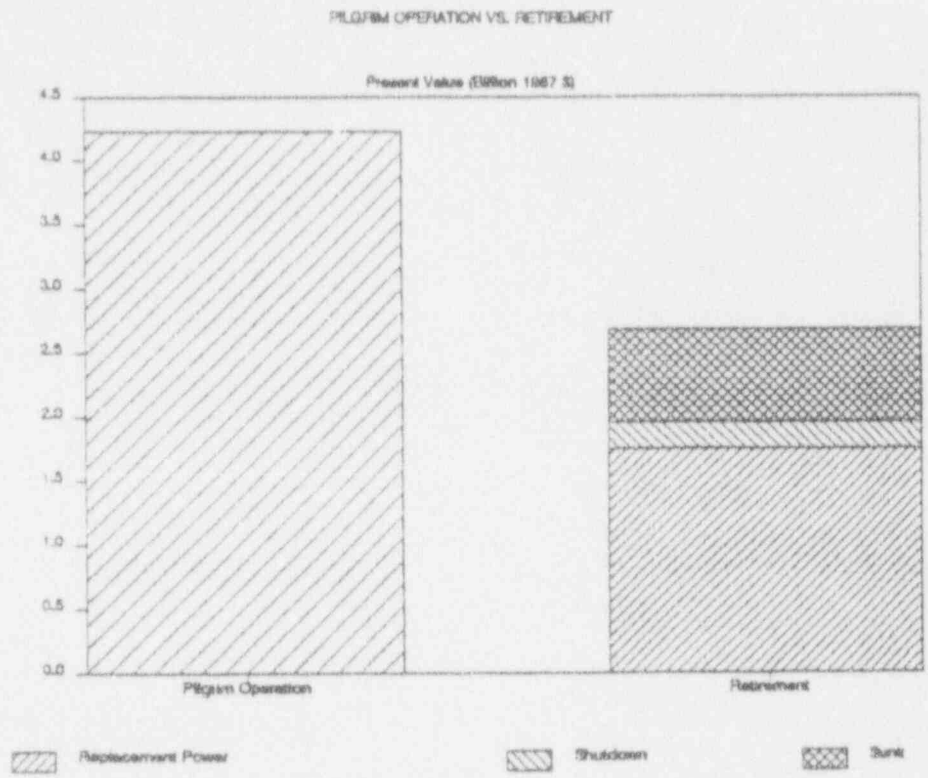
NUCLEAR LEMON



RATEPAYER SAVINGS FROM RETIRING THE PILGRIM NUCLEAR POWER PLANT

Massachusetts Public Interest Research Group
(MASSPIRG)

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ABOUT THE AUTHOR

Alan Nogee has been an Energy Policy Analyst for over ten years. He is author of two major national reports on utility policy -- *Rate Shock: Confronting the Cost of Nuclear Power,* and *Gambling for Gigabucks: Excess Capacity in the Electric Utility Industry* -- and numerous articles. He has testified or spoken by invitation to the energy committees of the U.S. Senate, House of Representatives, National Governors' Association, National Conference of State Legislatures, and regulatory agencies and legislative committees in several states. Before joining MASSPIRG in May, 1987, he was an Energy Analyst with Environmental Action Foundation, in Washington, D.C., and for consumer and environmental groups in Philadelphia, Pennsylvania.

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EXECUTIVE SUMMARY

This study examines the costs and benefits of permanently closing the Pilgrim nuclear plant, and replacing it with alternatives that are currently available to Boston Edison (BECO). Using conservative assumptions which are likely to underestimate Pilgrim's costs, and to overestimate the cost of alternatives, MASSPIRG has found that:

1. Utility customers would save at least $1.5 billion (present value) over the next 25 years by closing Pilgrim, if future Pilgrim costs were to follow historical trends for the plant. These savings would occur even if ratepayers had to pay for the full utility investment in the plant to date, including the same profit the companies would have earned if the plant had operated.

2. If trends at Pilgrim improved to the most optimistic levels that could reasonably be hoped for, utility customers would still save money by retiring Pilgrim, even if they had to pay for the full sunk investment in the plant.

3. Even under Edison's own assumptions, which are unrealistic, ratepayers would likely benefit from Pilgrim retirement, if the Massachusetts Department of Public Utilities required utility customers and investors to share the cost of past investment in Pilgrim according to traditional regulatory practice.

This study starts with the same figures and uses the same methods of analysis employed by BECO in a recent presentation to the Massachusetts Executive Office of Energy Resources (EOER). The utility's assumptions about future Pilgrim performance and major costs are compared to past performance and cost trends at Pilgrim and other U.S. nuclear plants, and alternative assumptions and cost projections are developed.

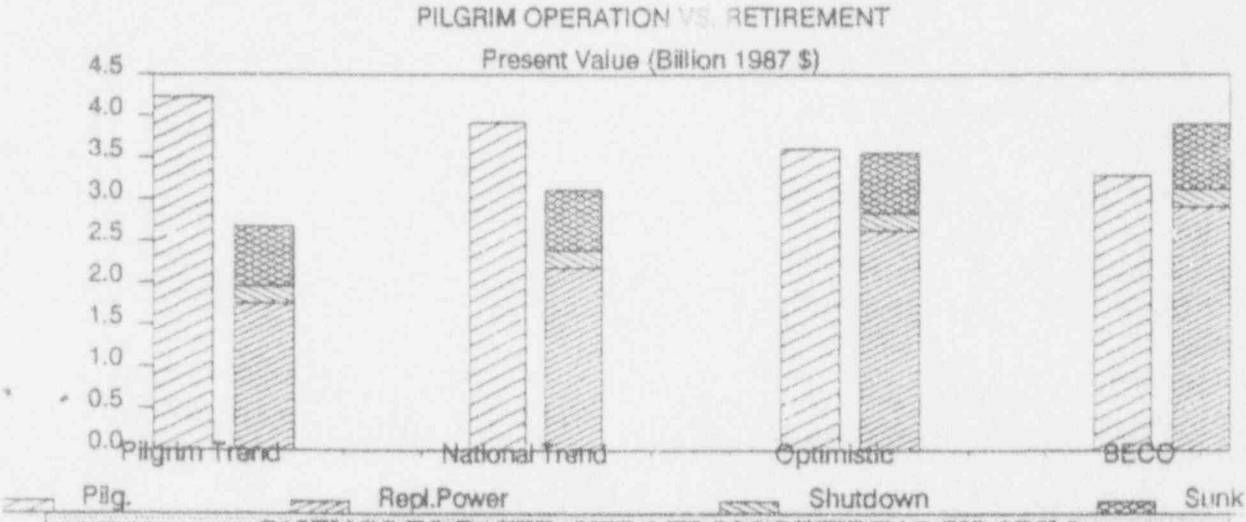
In order to err on the side of *underestimating* Pilgrim costs, MASSPIRG uses a number of unrealistically low Edison estimates in all projections. The costs of nuclear fuel, nuclear waste disposal and of dismantling Pilgrim at the end of its operating life are unchanged from BECO projections. It is assumed that the 15-year-old Pilgrim plant could operate for a total of 40 years, although no nuclear plant has operated for longer than 26 years. To be as favorable to Pilgrim as possible, MASSPIRG also assumes that the cost of replacement parts and safety upgrades will level off, and that Pilgrim performance will not deteriorate with age.

Replacement power for Pilgrim is readily available from at least two sources. First, Pilgrim's owners could "mine" electricity that is currently wasted by inefficient lighting, appliances, and other electrical equipment. A report to Edison's Board of Directors indicated the potential to reduce the utility's electric demand by 1,000 megawatts (Mw), at an average cost of less than two cents per kilowatt hour saved. Second, Pilgrim's owners could purchase electricity from small power producers and cogenerators. Independent power producers have bid to supply Boston Edison with 1,848 Mw by 1992. Pilgrim capacity is 670 Mw.

While some of the independent facilities have environmental problems, the combined potential of the efficiency improvements and independent power producers could replace Pilgrim and meet Edison's projected demand growth with over 1,000 Mw to spare. In order to *overestimate* the cost of replacing Pilgrim, it is assumed that *all* the efficiency savings go to displace demand growth, with the cost of power to replace Pilgrim based on a range of bids from cogeneration and small power facilities.

The table and figure below summarize the savings to ratepayers from retiring Pilgrim under various assumptions. The "Pilgrim Optimistic Case" (most favorable to Pilgrim) combines the *lowest* reasonable level of Pilgrim costs with the *highest* level of replacement power costs. The "National Trend Case" assumes that the rate of escalating costs at Pilgrim *improves* to the level of the average nuclear plant with Pilgrim's characteristics (age, type, location, etc.), and a moderate level of replacement power costs. The "Pilgrim Historical Trend Case" assumes that Pilgrim costs continue to escalate at their historic rates, and assumes the lowest level of replacement power costs.

All cases show savings to ratepayers from retiring Pilgrim. MASSPIRG therefore recommends that the Pilgrim plant be permanently closed. The Department of Public Utilities should allow no recovery of any future utility investment in the plant.



SAVINGS TO RATEPAYERS FROM RETIRING PILGRIM

	Ratepayers Pay Sunk Costs	Investors Pay Sunk Costs
Pilgrim Historical Trend Case	$1.56 billion	$2.28 billion
National Trend Case	$813 million	$1.54 billion
Pilgrim Optimistic Case	$49 million	$773 million
BECO	-$611 million	$168 million

1. Introduction -- Nuclear Costs and Cancellations

The Pilgrim nuclear power plant, in Plymouth, Massachusetts, is the focus of intense controversy over health and safety issues. (See, for example, *No Exit: The MASSPIRG Survey of Pilgrim Evacuation Planning*, September 1987.) Relatively little attention, however, has been paid to the increasing cost of operating the Pilgrim plant.

When Pilgrim was first turned on in late 1972, it appeared to be a relatively inexpensive source of electric power. Built for $232 million, Pilgrim's construction cost about three times as much per kilowatt of capacity* as an oil- fired plant. But uranium fuel was so much cheaper than oil, especially after the oil embargo of 1973, that the total cost of owning and operating the nuclear plant was less.

It is worth noting that some nuclear costs -- such as for research and development, fuel processing and insurance -- were heavily subsidized by federal tax dollars.[1] The Price-Anderson Act, passed by the U.S. Congress in 1957, limited industry liability for nuclear accidents, thereby relieving it of having to consider fully the economic risks of nuclear generation. Other costs -- for disposing of nuclear wastes and dismantling the plant at the end of its operating life (decommissioning) -- could not be reliably estimated then or now, since the required technologies still have not been demonstrated.[2]

During the 1970s, the cost of building new nuclear plants escalated dramatically. Nuclear construction costs increased by over twice the inflation rate, and nearly twice as fast as the cost of building coal-fired plants.[3] Major causes of the increases included technical problems that were identified as nuclear plants gained operating experience, new safety regulations imposed by the Nuclear Regulatory Commission (NRC), and management failures to anticipate and respond adequately to these pressures.[4]

As a result of increasing nuclear construction costs, and a drop in electricity demand growth, many orders for nuclear plants were canceled in the 1970s and 1980s. Over 110 nuclear plants -- almost half of the total number that utilities had ordered -- were canceled in various stages of construction, including a second unit planned for the Pilgrim site.[5]

*Power plant capacity is measured in watts. A kilowatt (Kw) is equal to 1,000 watts, enough power to light ten 100-watt light bulbs. A megawatt (Mw) equals one million watts or 1,000 kilowatts. An amount of electricity generated over a period of time is measured in kilowatt hours. A one megawatt plant operating at full capacity for 1 hour would produce 1,000 kilowatt hours (Kwh) of electricity. Pilgrim's capacity is 670 MW, of which Boston Edison owns 74.27 percent. Other owners are: Commonwealth Electric -- 11 percent, Eastern Utilities -- 10.5 percent, Massachusetts Municipal Wholesale Electric -- 3.73 percent, and Newport Electric -- .5 percent. For simplicity, Pilgrim will be treated in this report as if it were entirely owned by Boston Edison.

The same factors that caused construction costs to skyrocket for new nuclear plants have also increased the costs of older plants. Large expenses have been required for replacement equipment and safety improvements, called "capital additions," and for major repairs. In addition to work needed to bring older plants up to new safety standards, many nuclear parts and systems have worn out sooner than expected.[6] For the U.S. nuclear industry as a whole, capital additions increased by an average of 13 percent a year, after adjusting for inflation, between 1970 and 1986. Operation and maintenance costs increased by an average of over 11 percent a year, after inflation, during the same period. In addition, the majority of nuclear plants failed to perform as reliably as their owners expected, experiencing many more shutdowns than other types of power plants.[7]

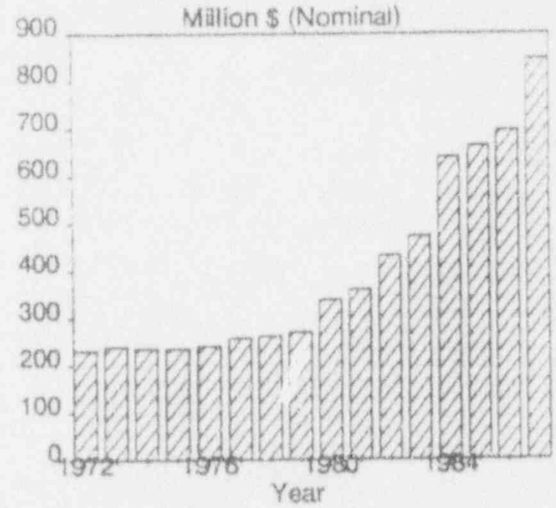
As a result of these increasing capital and operating costs, some utilities have begun to take a hard look at the cost of continuing to operate nuclear plants. In March, 1986, the Washington Public Power Supply System (WPPSS) temporarily closed its two-year-old operating reactor because it was more expensive to operate than oil or gas-fired plants.[8] In May, 1987, the Dairyland Power Cooperative, in Wisconsin, permanently shut down its 18-year-old LaCrosse nuclear plant because it was no longer competitive with alternatives.[9]

The Pilgrim nuclear plant has been subject to the same cost trends as other nuclear plants. **In fact, between 1980 and 1985, Pilgrim had the second most expensive capital additions per kilowatt of any nuclear U.S. power plant, and has become one of the most expensive nuclear plants in the country.**[10] By the end of 1987, Boston Edison (BECO) will have sunk $614 million into Pilgrim *above* its $232 million original cost, bringing the total investment in the plant to $846 million (Figure 1). Even after adjusting for inflation, Boston Edison has spent 40 percent more for replacement and new parts for Pilgrim than it initially spent building the plant.

Largely as a result of these capital additions, Boston Edison's own estimates show that in 1988, electricity from Pilgrim will cost 6.53 cents per Kwh, almost twice as much as power from oil-fired plants, at a cost of 3.34 cents per Kwh (Figure 2).

Figure 1

PILGRIM CAPITAL COST

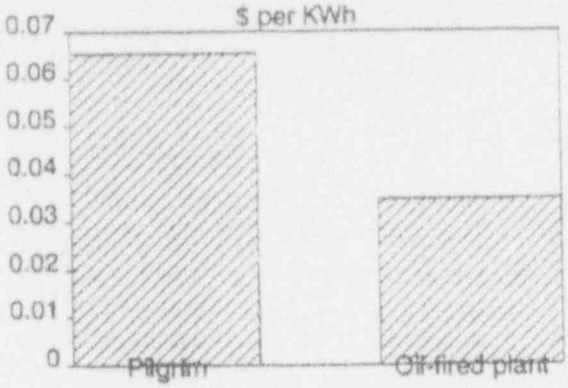


BECO also recognizes that continued Pilgrim operation will require ongoing capital additions. **Edison estimates that keeping Pilgrim running will require another $1.4 billion investment in capital additions over the 25 years it estimates for Pilgrim's remaining life. Pilgrim's total capital cost would then equal over $2.25 billion dollars -- almost ten times the initial construction cost of the plant (Figure 3).** Moreover, independent estimates discussed in the following chapters of this

Figure 2

ELECTRICITY GENERATION COST -- 1988

$ per KWh



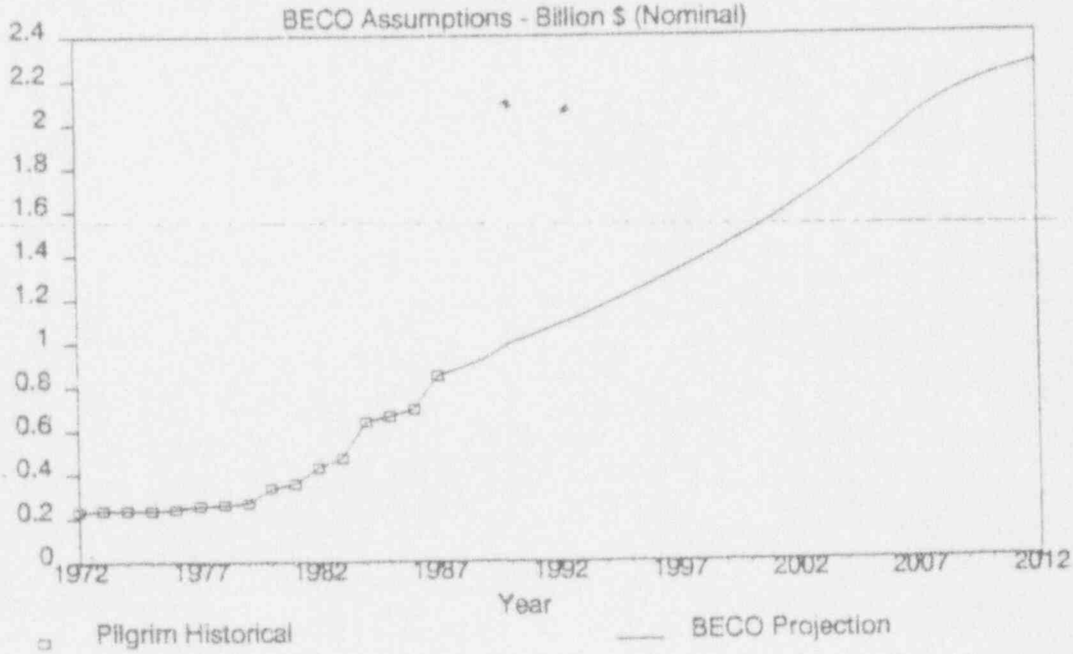
report indicate that capital additions and other costs are actually likely to exceed BECO estimates. These escalating costs require serious consideration of whether continued investment in and operation of Pilgrim is economical.

In April, 1986, the Pilgrim plant experienced two "unexplainable automatic shutdowns," or "scrams." The NRC ordered the plant to remain closed until serious problems with Pilgrim and its management are resolved. During this time, Boston Edison has chosen to make major upgrades in the Pilgrim plant -- budgeting over $150 million in capital additions and nearly $100 million in maintenance costs in 1987 -- to return the Pilgrim plant to service. This study looks at whether it makes more economic sense to retire Pilgrim than to continue investing hundreds of millions of dollars in it. Chapter 2 looks at Boston Edison's projections of Pilgrim costs, compares BECO assumptions about nuclear cost trends to the historical trends at Pilgrim and other nuclear plants around the country, and develops more realistic estimates of future Pilgrim costs. Chapter 3 examines the cost of retiring the Pilgrim plant and replacing it with alternatives currently available to Boston Edison. Chapter 4 summarizes the report's overall findings and presents MASSPIRG's recommendations.

Figure 3

PILGRIM CAPITAL COST PROJECTION

BECO Assumptions - Billion $ (Nominal)



2. The High Cost of Operating Pilgrim

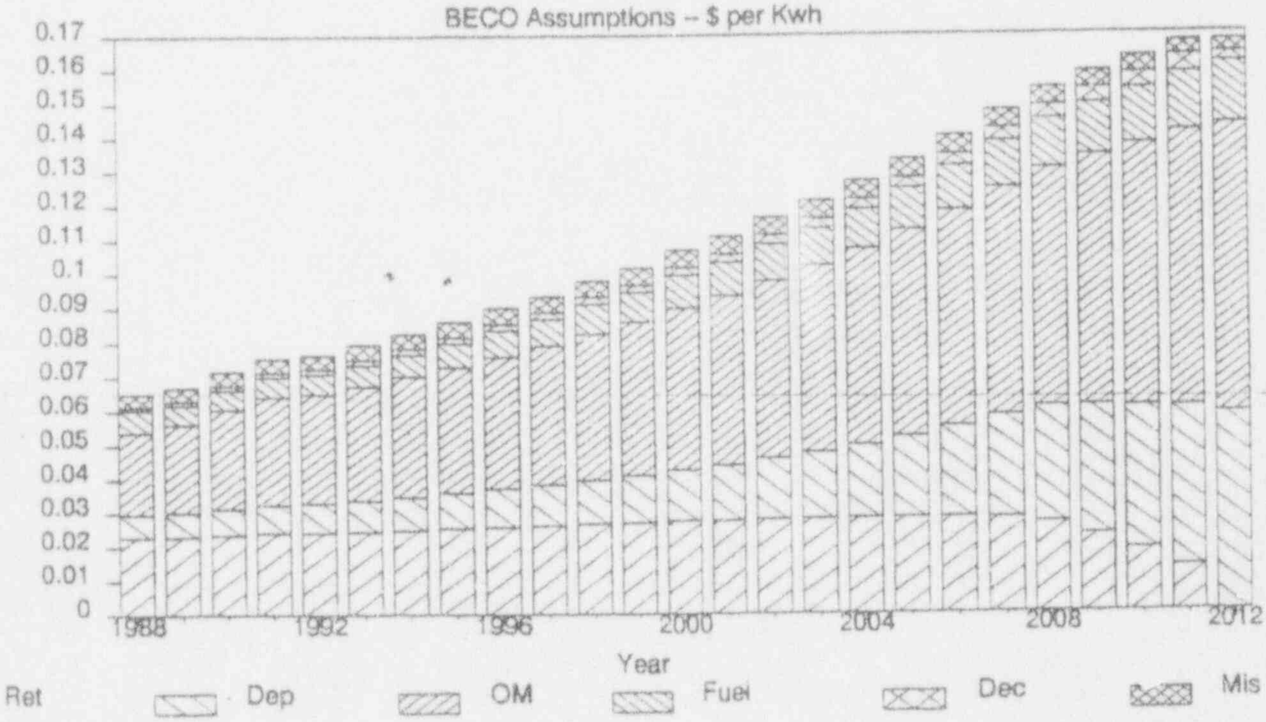
A. Boston Edison projections

In May, 1987, Boston Edison developed projections of Pilgrim's future costs in response to a request by the Massachusetts Executive Office of Energy Resources (EOER). Edison's projections were also sent to the Office of the Attorney General, the Department of Public Utilities, and upon request, to MASSPIRG.

BECO projects that the cost of electricity from the Pilgrim plant will increase from 6.53 cents per kilowatt hour (Kwh) in 1988 to 16.76 cents per Kwh in 2012 (Figure 4), primarily as the result of inflation. Another way of looking at the cost of Pilgrim is to add up the total bill to ratepayers for the plant's costs over the remainder of its expected life. The "present value" of BECO's estimate of future Pilgrim costs (discounting future dollars at the 10.55 percent annual rate Edison uses to account for the declining value of money over time) is $3.3 billion in 1987 dollars.

Figure 4

PILGRIM COST COMPONENTS



(See next page for explanation.)

How Pilgrim Costs Are Calculated

The graph on the opposite page shows how much Boston Edison expects to charge its customers each year for electricity from Pilgrim, based on the standard rules of utility regulation. Electric companies are allowed to recover most operating and fuel expenses directly in rates as they are incurred each year. Utility investment in major plant and equipment is recovered over the operating life of the plant through depreciation charges. Utilities are also allowed to charge customers for their financing costs, including a profit on their investment.

The bottom section of each bar in the graph shows the financing charges, or return, that BECO expects to earn on its Pilgrim investment. The return consists of interest payments on debt borrowed to finance Pilgrim, and the profits BECO expects regulators to allow it to earn on its investment in the plant. The next area up represents depreciation of BECO's Pilgrim investment. The third area from the bottom depicts operation and maintenance (O&M) charges, which include labor and direct operating expenses. Above O&M are the costs for nuclear fuel, including current estimates of waste disposal costs. The next area of the graph shows how much money is collected to pay for decommissioning the plant at the end of its operating life. The top area indicates miscellaneous expenses, such as insurance and local property taxes.

BECO expects to earn a 14.4 percent rate of return on its Pilgrim investment. About 38 percent of that amount is paid to the federal government for income taxes. Every billion dollars invested in Pilgrim thus translates into $164 million in charges per year in rates. Each year, 1/40 of the investment in Pilgrim is charged to ratepayers for depreciation, and that amount is subtracted from the next year's "rate base," an account in the utility's books representing the amount of investment on which the utility can earn a return. The current fee for waste disposal assessed by the Department of Energy is one-tenth of a cent per KWh. Decommissioning cost charges are calculated to accumulate the $326 million (in 1986 dollars) Edison estimates will be necessary to dismantle the nuclear plant in the year 2012. Property taxes average about 1.8 percent of the value of the plant in rate base. Insurance costs increase over time from $5-15 million a year.

The cost per kilowatt hour is calculated by dividing the total annual cost by the number of Kwh generated per year. KWh per year is a function of capacity factor (see Chapter 3, Section B) multiplied by 8760 hours per year times the 670,000 kilowatt size of the plant. Edison assumes a 70 percent capacity factor for future Pilgrim operation.

But based on historic nuclear cost trends, Edison is greatly underestimating Pilgrim costs. Projecting the total cost of electricity from a power plant involves making numerous assumptions about various cost components, as well as the overall operating performance of the plant. Three assumptions in particular dominate the final results: the rate of capital additions, operation and maintenance (O&M) expenses, and the amount of time the plant can be expected to operate (capacity factor).

B. MASSPIRG projections

MASSPIRG has compared Edison assumptions in each of these areas to actual performance and cost trends at Pilgrim and other nuclear plants around the country. The specific results of these comparisons are presented in Appendix B. In general, Edison projections assume that the past performance of Pilgrim and other nuclear plants provide *no guide* to future costs. Consistent historical trends – both at Pilgrim and at nuclear plants around the country -- are assumed to immediately stop.

O&M costs, which have increased nationally by 11.4 per year, after adjusting for inflation, and by 13.8 percent annually at Pilgrim, are projected to increase at only 0.5 percent per year henceforth. Capital additions, which have escalated nationally at 13 percent per year after inflation, and much faster at Pilgrim, are also forecast by Edison to increase by 0.5 percent per year in the future. Despite the fact that Pilgrim has had a lifetime capacity factor of only 50 percent, and the national average for nuclear plants is 60 percent, Edison predicts that Pilgrim will average a 70 percent capacity factor in the future.

Nuclear utilities around the country have been making similar assumptions for many years. Each year, the utilities project that nuclear costs will freeze at then-current levels. Instead, real costs have continued to rise. The basic forces that have run up nuclear costs in the past will continue to increase costs in the future. These factors include technical problems discovered as nuclear plants gain more operating experience, unresolved generic nuclear safety issues, the aging of reactor parts, and the potential for both small and large nuclear accidents to create new regulatory requirements.[11] (See Appendix C for additional discussion.)

It is therefore important to examine more realistic assumptions for nuclear costs. MASSPIRG looks at three alternative assumptions for each major nuclear cost component. In a "Pilgrim Historical Case," future costs are assumed to continue to escalate in line with historical trends for the Pilgrim plant. In a "National Trend Case," Pilgrim cost trends are predicted to improve to match those of the average plant having Pilgrim's characteristics. For a "Pilgrim Optimistic Case," it is assumed that future Pilgrim costs will improve to a level substantially better than would be expected based on either Pilgrim or national trends.

The detailed basis of MASSPIRG's alternative projections are presented in Appendix B. Figures 5 and 6 illustrate the effect of the revised assumptions on the annual cost per Kwh and on the total present value of Pilgrim costs to

Figure 5

PILGRIM ANNUAL GENERATION COSTS

Alternative Scenario Analysis

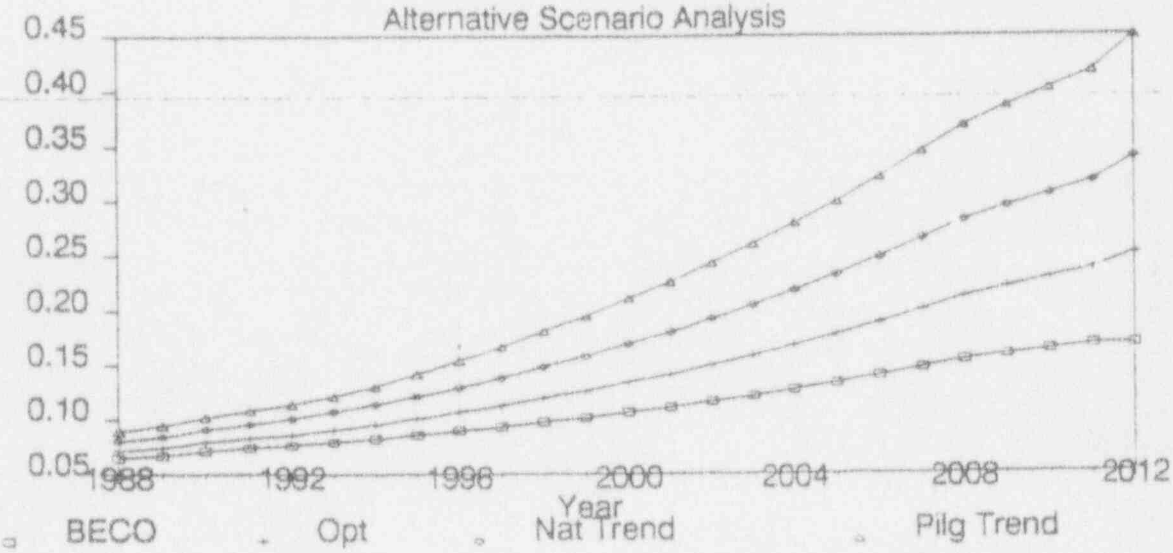
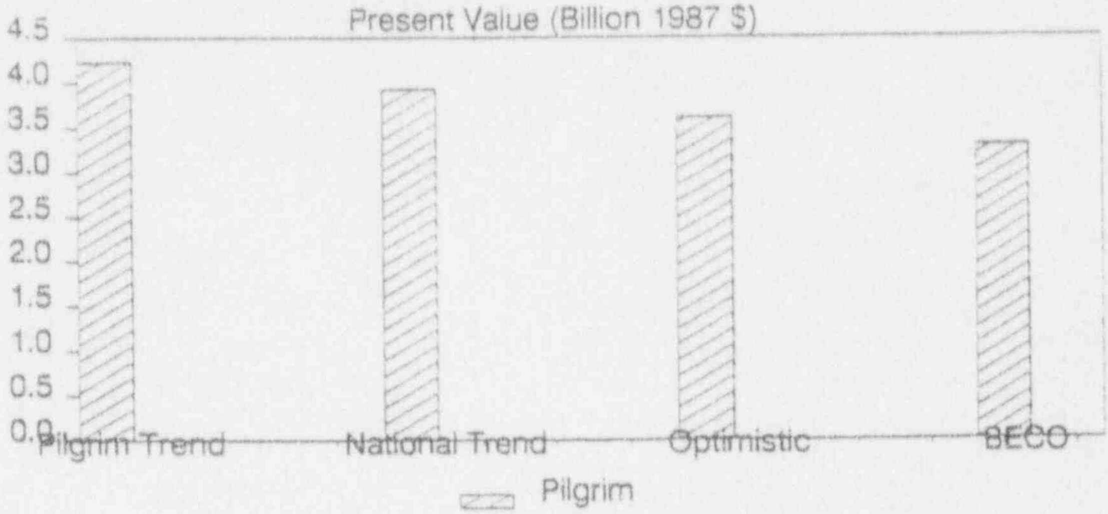


Figure 6

RANGE OF PILGRIM TOTAL COSTS

Present Value (Billion 1987 $)



ratepayers, respectively.

All three MASSPIRG cases share a number of *extremely* conservative assumptions. In general, nuclear costs are assumed to be increasing according to linear trends (i.e., a constant number of dollars per year, after adjusting for inflation) rather than according to exponential trends (i.e., a constant percentage increase per year, after inflation). The trend of increasing capital additions is still assumed to level off in a few years, despite evidence that it may actually be accelerating. Plant performance is not assumed to deteriorate with age, despite evidence of declining capacity factors, particularly at salt-water-cooled plants like Pilgrim.

For simplicity, and to be as favorable to Pilgrim as possible, this report also adopts a number of other Edison assumptions which are biased in favor of Pilgrim. The Pilgrim plant is assumed to be operable until the year 2012 -- a total of 40 years from when it entered service. The oldest commercial nuclear plant has operated for only 26 years, and 14 reactors have been retired after less than 20 years of operation. Pilgrim's operating license currently expires in the year 2008, and would have to be extended by the NRC in order for the plant to operate until 2012.
Real nuclear fuel costs are assumed to remain stable, even though approximately half of the uranium used in domestic nuclear plants is imported, much of it from politically unstable countries such as South Africa.[12]
BECO's estimates for nuclear waste disposal and for dismantling the radioactive plant are used, despite the fact that the necessary technologies have not yet been demonstrated and there is therefore enormous uncertainty around estimating these costs. And it is assumed that no serious nuclear accidents occur at Pilgrim or at any other U.S. nuclear plant. The conservative nature of these assumptions is discussed in more detail in Appendix C.

3. Economic Benefits of Retiring Pilgrim

There are three categories of potential costs to ratepayers for retiring Pilgrim at this time. First, there is the cost of replacement power. Second, there are costs to shut the plant down and decommission it, which must be paid whether the plant is retired now or later. Third, there is the potential cost of paying for past investment in the plant. Each cost will be considered separately.

A. Replacement power

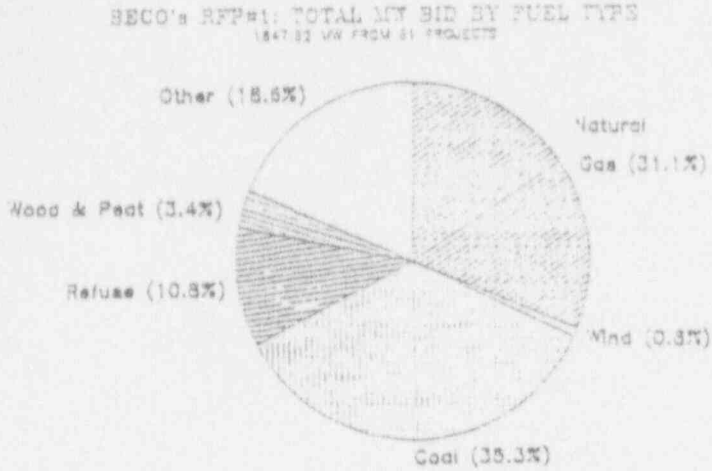
The main cost of retiring Pilgrim would be to replace the electricity produced by the nuclear plant. As demonstrated in the recent New England Energy Policy Council study, *Power to Spare*, the least expensive means of obtaining new power supplies is to "mine" the electricity that is now wasted by inefficient lighting, appliances, and other electrical equipment in our offices, factories and homes. **Utilities around the United States have found that they can finance efficiency improvements for their customers at an average cost of less than two cents per Kwh.[13] That is less expensive than operation and maintenance costs alone at Pilgrim.** A report to Boston Edison's Board of Directors in March, 1987, found that cost-effective efficiency improvements could reduce electric demand in Boston Edison's service territory by as much as 1,000 Mw over the next 15 years.[14]

Another readily available source of replacement power for Pilgrim would be the purchase of electricity from new plants built and owned by independent small power producers, generally referred to as "Qualifying Facilities" or "QFs." Since the passage of the federal Public Utility Regulatory Policies Act (PURPA) of 1978, which required utilities to purchase power from independent producers at fair prices, there has been a rapid increase in the development of such facilities throughout the country.

In January, 1987, in response to rules enacted by the Massachusetts Department of Public Utilities, Boston Edison sent a Request for Proposals to potential developers to supply 200 megawatts (Mw) of Edison's power needs by 1992. The utility's projection of future oil costs was set as the ceiling price for acceptable offers. In June Edison received bids from 61 projects, representing a total of 1848 Mw. The number of proposals received was well above the utility's expectations. In fact, in its April 1987 forecast, the New England Power Pool had projected that only 1391 Mw of independent power would be available for the entire region by the year 2002.[15]

The majority of the proposals were for cogeneration facilities -- which produce useful heat and electricity in the same process -- and other small power facilities using a variety of fuels

Figure 7



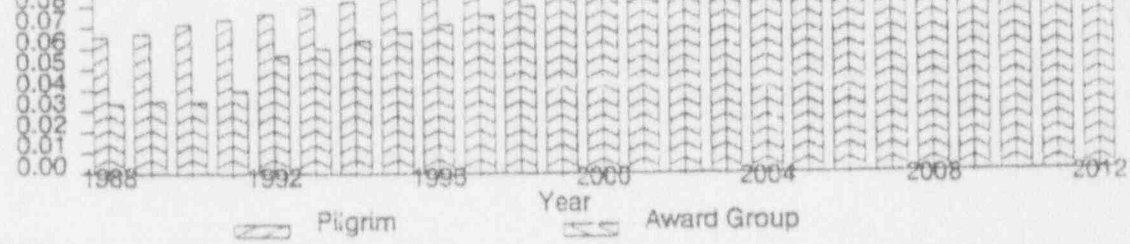
(Figure 7). Over 240 Mw would be produced using renewable energy sources, such as biomass, wind or hydropower.

Some of the projects, particularly the 200 Mw of plants which would burn refuse as fuel, may present environmental problems. MASSPIRG does not necessarily endorse all of the proposed QFs. However, the combination of energy efficiency improvements and the large number of small power and cogeneration projects provides a more than adequate pool of potential replacement power for Pilgrim. **The combined potential of energy efficiency improvements and independent power projects exceeds Edison's share of the Pilgrim plant and its forecast of power needed to meet increased demand through the year 2012 by over 1,100 Mw.**[16]

Nine QF projects, representing 350 Mw, were selected by Edison as an initial "Award Group" for final contract negotiation. **The average Award Group bid was significantly below the price of Pilgrim-generated electricity, even using all of Boston Edison's Pilgrim cost assumptions (Figure 8).**

If Pilgrim were to be replaced, there would be a second round of bidding. It is quite likely that many bids would be lowered given the large, and previously unknown, surplus of potential supply over Edison's demand. In the first round, potential developers were bidding primarily against BECO's extremely high projection of oil price increases. The utility forecasts oil prices to increase at an average rate of over ten percent a year, approximately five percent above the assumed inflation rate between now and the year 2012. Oil prices would increase from their current $20 per barrel to $166 per barrel in 2012, or to over $53 a barrel in 1987 dollars adjusted for inflation.

Figure 8



To be as favorable to Pilgrim as possible, however, the Award Group bids are assumed by MASSPIRG to represent the low end of a range of replacement power costs. Efficiency savings are assumed to be used entirely to displace demand growth rather than to replace Pilgrim. The average bid of the next block of 740 Mw is used as a middle estimate of Pilgrim replacement costs. And the average bid of all the non-Award Group projects is adopted as a high estimate of replacement power costs.

Using BECO's assumption of a 70 percent capacity factor for Pilgrim, the total present value of replacement power needed would range from $2.5 billion, based on the Award Group, to $2.9 billion, based on the average non-Award Group bid, through the year 2012 (Figure 9). If one assumes lower Pilgrim capacity factors, replacement power would cost even less.

All the proposed QFs have projected in-service dates before 1992, with 400 Mw expected to be available by the end of 1990. For this study, it is assumed that all QFs begin operation in 1992. Until that time, replacement power costs are assumed to equal energy costs from reserve oil-fired plants, plus an additional charge by the New England Power Pool for providing reserve capacity. The 1987 New England Power Pool forecast shows a more than adequate reserve margin of generating capacity through 1992 -- even if the Pilgrim, Seabrook, and Maine Yankee plants are not in service.[17]

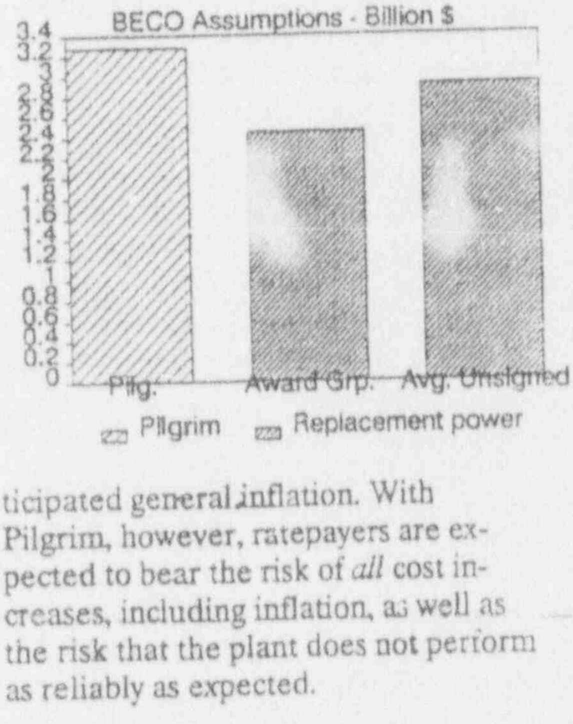
Reliance on non-utility power plants poses certain obvious risks to a utility, since it will not control the construction or operation of the QF plants. These risks must be weighed against risks associated with Pilgrim, however. Pilgrim could be closed by federal regulators because of an accident at another nuclear plant, as well as by incidents at the plant itself. The diversity of the QF projects makes it more likely that a given amount of power will be available at all times.

The QF contracts also provide insulation from important financial risks, since they are based on payment per Kwh produced. Their private owners thus assume the risks of cost overruns, poor plant performance and profitability. Most of the Award Group contracts are tied to the Consumer Price Index, thereby requiring utility customers to bear only the risk of unan-

Figure 9

PILGRIM VS. REPLACEMENT POWER COSTS

BECO Assumptions - Billion $



ticipated general inflation. With Pilgrim, however, ratepayers are expected to bear the risk of *all* cost increases, including inflation, as well as the risk that the plant does not perform as reliably as expected.

B. Other shutdown costs

A decision to retire Pilgrim at this time would involve some costs in addition to replacement power. Decommissioning costs, for instance, would still have to be incurred whenever Pilgrim is retired. Actually, since the cost of decommissioning is likely to increase as the plant becomes more radioactive, it would almost certainly be cheaper to decommission it earlier. To be conservative, however, these potential savings are not considered here. Costs that would clearly have to be incurred to shut Pilgrim down must be added to the cost of replacement power (or subtracted from the cost of Pilgrim) to evaluate the economics of early retirement of the plant.

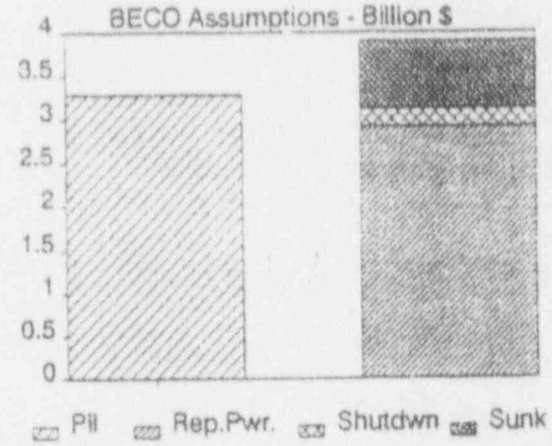
In addition to direct decommissioning costs of $126 million in 1987 dollars, BECO estimates that closing Pilgrim will require additional operation and maintenance costs over a five year decommissioning period. The total decommissioning and shutdown costs add $206 million, in addition to the cost of replacement power, to the present value cost of retiring Pilgrim. Edison fails to include these costs in its analysis of continuing to operate Pilgrim, however, presumably because the costs would be incurred after the year 2012 -- the last year BECO looks at. In the MASSPIRG scenarios, the present value of the post-operation costs are included in both early and late retirement scenarios.

C. Sunk costs.

Another potential cost to retiring Pilgrim is repayment of the money that Edison has invested in the plant to date -- generally referred to as "sunk costs." Pilgrim sunk costs will total $846 million by the end of 1987. **In its analyses of the cost of retiring Pilgrim, BECO effectively assumes that ratepayers would pay for the utility's entire investment in Pilgrim, along with the same rate of profit it would earn if the plant were operated (Figure 10).**

Figure 10

PILGRIM OPERATION VS. RETIREMENT



In addition to its investment in the plant itself, Edison also includes a $50 million investment in an inventory of nuclear fuel and $20 million in materials and supplies in Pilgrim sunk costs. After the Pilgrim 2 unit was canceled, however, BECO was able to recover 64 percent of its investment in nuclear fuel by selling it to other utilities.[18] In the MASSPIRG scenarios, therefore, it is also assumed that BECO will recover 64 percent of its current investment in fuel, materials and supplies through sales to other utilities.

If Pilgrim were retired, it would actually be up to the Department of Public Utilities (DPU) to determine who should pay for Pilgrim sunk costs. Under a policy adopted in a Western Massachusetts Electric Company case in 1984, the DPU ruled that sunk cost recovery would no longer be allowed for investments that were not "used and useful" to utility customers, such as plants that were canceled while still under construction.[19] In a 1985 decision on excess capacity, the Department modified its policy to allow utilities to recover uneconomic investments over time, but without charging ratepayers for financing charges.[20] This policy, which is followed by most state utility commissions, results in a sharing of sunk costs between utility ratepayers and investors. Stockholders are also able to share their losses with the federal government, which allows generous tax deductions for investment losses.[21]

D. Alternative scenarios show savings from retiring Pilgrim.

Three scenarios were constructed to cover the widest reasonable range of assumptions for the costs of operating or retiring Pilgrim. The Pilgrim Optimistic Case combines all the assumptions

Table 1. ALTERNATIVE ASSUMPTIONS USED IN MASSPIRG PILGRIM PROJECTIONS

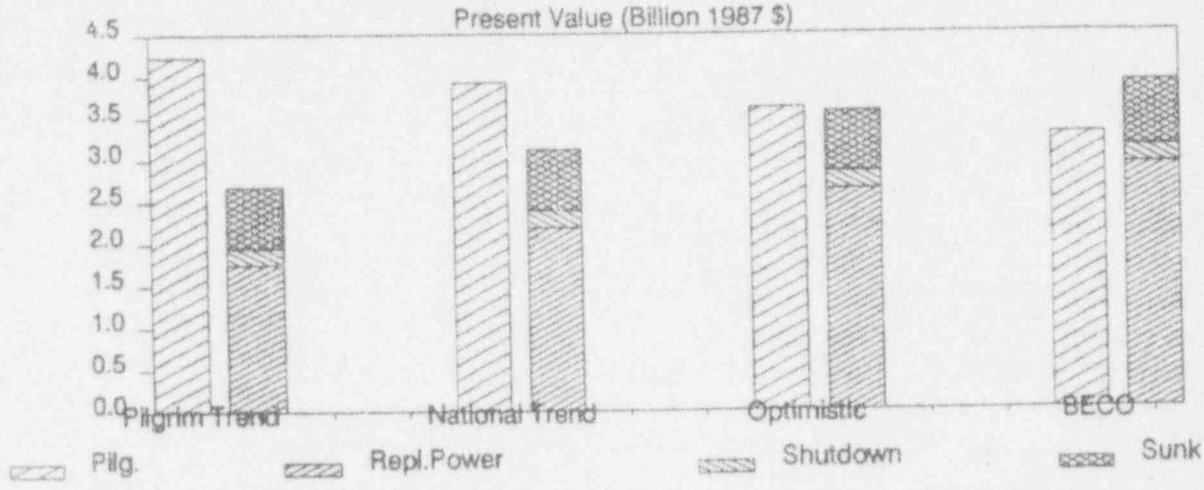
	Capacity Factor	Capital Additions	O&M Expenses	Replacement Power
Pilgrim Historical Trend Case	Pilgrim Historical 50%	Pilgrim Historical 10 years	Pilgrim Historical	Averge of Award Group QFs
National Trend Case	National Trend Pilgrim to 4/86 56%	National Trend 5 years	National Trend	Average of Next 740 MW QFs
Pilgrim Optimistic Case	National avg. all BWRs 63.2%	Pilgrim Low Historical 5 years	2% Real Escalation	Average of all 1327 MW Unsigned QFs
Boston Edison	70%	0.5% Real Escalation	0.5% Real Escalation	Average of all 1327 MW Unsigned QFs

Table 2. ADDITIONAL CONSERVATISMS IN ALL SCENARIOS

Nuclear waste disposal:	No increases from current BECO assumptions
Shutdown:	No savings from early decommissioning
Capacity factor:	No declining effect from salt-water cooling
Capital Additions:	No increases after 5-10 years BECO-assumed decreases in last five years of operation No repeat of 1984 and 1987 major repairs
O&M and Capital Additions:	Linear rather than exponential trend increases
Miscellaneous:	40-year lifetime No increases in nuclear insurance No serious accidents No societal costs No nuclear subsidies included in Plgrim costs

Figure 11

PILGRIM OPERATION VS. RETIREMENT



most favorable to Pilgrim -- the most optimistic projections of Pilgrim costs, and the highest price for replacement power, equal to the average bids of all non-Award Group QFs. The National Trend Case assumes that Pilgrim costs improve to the level predicted by the national trend for a plant with Pilgrim's characteristics. A middle estimate of replacement power is used, equal to the price of the least expensive 740 Mw of QF bids after the Award Group. The Pilgrim Historical Case assumes that all Pilgrim cost components follow the same trends they have in the past, and that replacement power could be obtained for the price of the Award Group bids from QFs. Table 1 summarizes the assumptions employed in each scenario. Table 2 lists the additional assumptions favorable to Pilgrim that were made in all MASSPIRG scenarios.

The alternative scenarios indicate that **the present value of savings to ratepayers from <u>retiring</u> the plant would range from $46 million to $1.6 billion over 25 years, even if ratepayers were to pay for all sunk costs (Table 3; Figure 11). The $1.6 billion savings is approximately equal to $540 for the average Edison residential customer.** If investors were to pay sunk costs, the savings from retiring Pilgrim would increase to a range of $769 million to

SAVINGS TO RATEPAYERS FROM RETIRING PILGRIM

	Ratepayers Pay Sunk Costs	Investors Pay Sunk Costs
Pilgrim Historical Trend Case	$1.56 billion	$2.28 billion
National Trend Case	$813 million	$1.54 billion
Pilgrim Optimistic Case	$49 million	$773 million
BECO Assumptions	-$611 million	$168 million

$2.3 billion. Detailed annual costs for all scenarios are presented in Appendix A.

Figure 12 illustrates how the present value of the cumulative savings from retiring Pilgrim changes over time in each scenario, assuming that ratepayers pay for the full sunk costs, including a profit on Pilgrim investment to date. The cumulative savings at any point in time is equal to the difference between total Pilgrim costs and the total costs of replacement power, shutdown and sunk costs to that time.

Graphs of cumulative savings are especially useful for looking at the effect of changing only one assumption at a time on the benefits of retiring Pilgrim. Figure 13 illustrates the effect of changing only the assumption about how regulators might deal with Pilgrim sunk costs if the plant were retired. The middle line represents the usual regulatory practice for plants canceled under construction, where ratepayers would repay all sunk costs over time but with the utility earning no profit on its sunk investment. In this case, it is assumed that Pilgrim sunk costs would be charged to ratepayers over the same 25 year period as they would have been if the plant had operated. **Under traditional regulatory practice, ratepayers would save money, at least through the year 2008, by retiring Pilgrim, even if all BECO assumptions about the plant's future costs hold.**

Figure 12

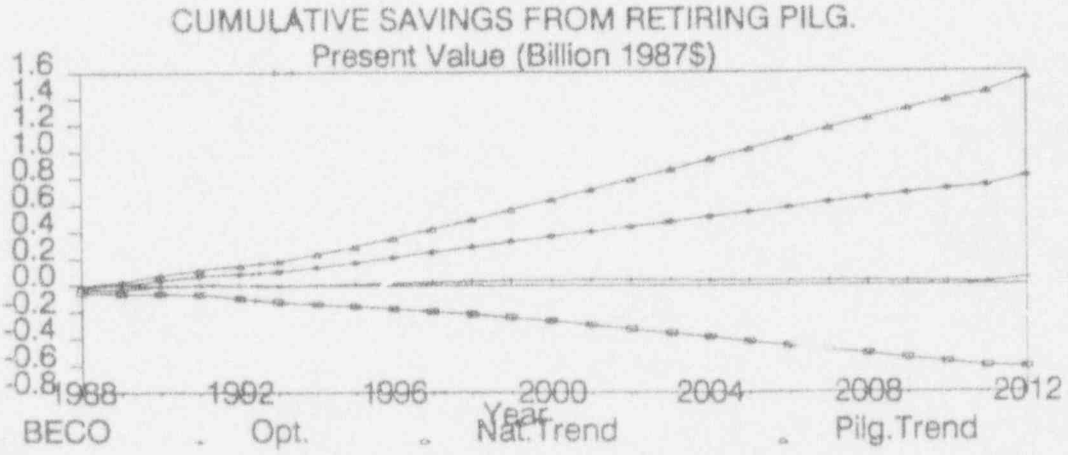
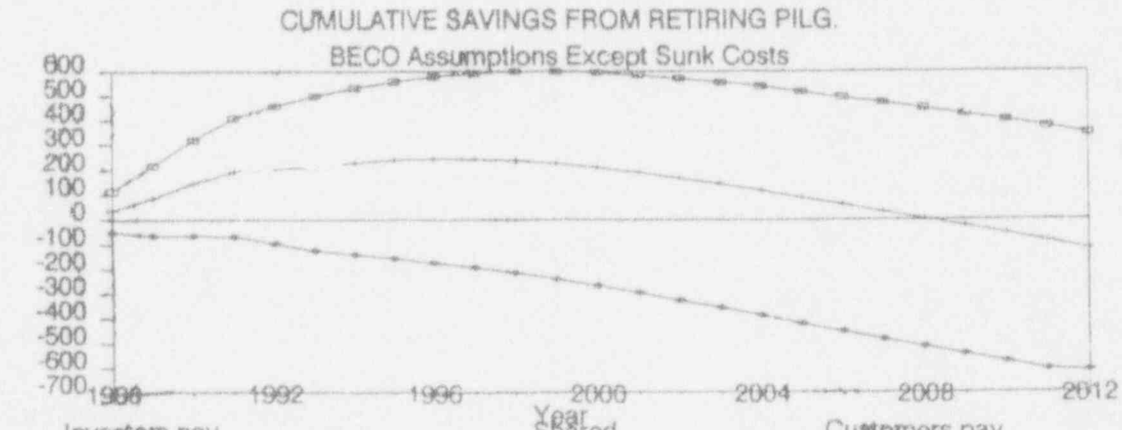


Figure 13



4. Conclusions and Recommendations

Retiring Pilgrim would clearly save utility customers money, under a wide range of reasonable assumptions, even if ratepayers have to pay a full return on the sunk costs of the plant. **The Pilgrim nuclear plant should therefore be immediately and permanently retired.**

While no state official or agency has the direct authority to order the shutdown or retirement of a nuclear plant, the Massachusetts Department of Public Utilities (DPU) is responsible for determining what, if any, utility investments and expenses can be charged to ratepayers, under a broad statutory mandate to ensure just and reasonable electric rates. If it were to determine that ongoing investment in Pilgrim were uneconomical, the DPU could prohibit its owners from financing or charging ratepayers for future investment in the plant.

MASSPIRG therefore recommends that the DPU disallow recovery of any additional Pilgrim investment, including the $150 million in capital additions Boston Edison has budgeted to spend in 1987. A second round of bidding from potential power suppliers should be initiated, with reasonable assumptions about Pilgrim costs used to set a target for acceptable bids. Energy efficiency contractors, who could sell energy savings to the utility, should also be encouraged to compete with QFs in bidding to replace Pilgrim.

A similar process for dealing with new power plant construction has recently been proposed to the DPU by the state Executive Office of Energy Resources.[22] Decisions to continue investing in plants that have already been in operation are no different from decisions to start new construction, or to complete partially built plants. In each case, the ongoing investment must be weighed against potential alternatives. New utility investment in power plants should be allowed only if it would be "used and useful" -- necessary to provide reliable electric service and the most economical alternative. To the extent that the Pilgrim plant cannot meet that test -- and this report finds that it cannot -- the plant should be permanently retired.

APPENDIX A

ANNUAL COSTS OF PILGRIM VS. ALTERNATIVES

BECO ASSUMPTIONS

(in millions of dollars)

Year	Capital Additions	Total Plant Year End	Annual Depreciation	Accumulated Depreciation	Net Plant Year-End	Deferred Tax	Materials	Fuel	Avg. Rate Base	Return on Rate Base	Income Tax	Depreciation	Insurance	Local Tax	Decommissioning	Fuel	O&M	<--- PILGRIM TOTAL ---> Annual Costs	Cost in Cents per kwh	Incremental (mil.)	Costs per kwh	<--- QFs ---> Cost in Cents per kwh	Cost (mil.)
1987	150	846	24	176	670	-104	20	51	562	58	27	24	5	11	4	1	97	227	5.5	1	0.0	3.3	34
1988	40	886	28	204	682	- 13	21	51	621	64	30	28	5	11	5	27	99	268	6.5	92	2.2	3.5	144
1989	40	926	29	233	693	-122	22	50	623	64	30	29	5	11	5	24	107	276	6.7	126	3.1	3.6	149
1990	70	996	32	265	731	-130	23	50	640	66	31	32	5	12	5	24	120	294	7.2	152	3.7	3.7	152
1991	40	1036	34	299	737	-138	24	50	654	68	32	34	6	12	5	24	125	305	7.4	169	4.1	4.2	174
1992	42	1078	36	335	743	-143	26	50	655	68	32	36	6	12	6	24	131	314	7.6	185	4.5	5.7	232
1993	44	1122	38	373	749	-147	27	54	661	68	32	38	6	12	6	26	138	326	7.9	202	4.9	6.1	251
1994	46	1168	41	414	754	-146	28	56	670	69	33	41	6	12	7	27	145	339	8.3	240	5.8	6.6	272
1995	49	1217	43	457	760	-143	30	60	683	71	33	43	7	12	7	29	152	353	8.6	258	6.3	7.2	294
1996	51	1268	46	503	765	-139	31	66	697	72	34	46	7	13	7	31	160	370	9.0	278	6.8	7.8	320
1997	54	1322	49	553	769	-136	33	67	706	73	35	49	7	12	8	32	168	384	9.3	294	7.2	8.5	349
1998	56	1378	53	606	772	-133	34	75	721	74	35	53	8	12	8	36	176	403	9.8	316	7.7	9.2	378
1999	59	1437	57	663	774	-129	36	75	726	75	36	57	8	12	9	36	185	418	10.2	334	8.1	10.2	420
2000	62	1499	62	725	774	-126	38	84	739	76	36	62	9	13	9	40	194	439	10.7	358	8.7	11.1	457
2001	65	1564	67	792	772	-121	40	84	742	77	36	67	9	13	10	40	204	455	11.1	377	9.2	12.0	491
2002	68	1633	73	866	767	-115	42	92	752	78	37	73	9	12	11	44	214	478	11.6	402	9.8	13.2	541
2003	72	1705	80	946	759	-105	44	94	755	78	37	80	10	12	11	45	225	498	12.1	425	10.3	13.9	573
2004	75	1780	88	1035	746	-93	46	99	760	79	37	88	10	12	12	47	236	522	12.7	451	11.0	15.1	621
2005	79	1859	98	1133	727	-78	48	105	762	79	37	98	11	11	13	50	248	547	13.3	478	11.6	16.5	677
2006	83	1942	110	1242	700	-60	51	111	761	79	37	110	11	11	14	53	260	575	14.0	508	12.4	17.8	729
2007	87	2030	124	1366	663	-37	53	118	754	78	37	124	12	11	15	56	273	605	14.7	540	13.2	18.6	765
2008	70	2100	140	1506	594	-9	43	125	718	74	35	140	13	9	16	59	287	633	15.4	570	13.9	19.9	819
2009	56	2156	155	1661	494	26	34	94	619	64	30	155	13	8	17	63	301	652	15.9	591	14.4	21.2	870
2010	45	2200	172	1834	367	66	27	62	500	52	24	172	14	6	19	67	316	669	16.3	610	14.8	22.5	922
2011	36	2236	192	2026	210	115	22	31	361	37	18	192	15	3	21	71	332	688	16.7	629	15.3	23.8	979
2012	29	2265	239	2265	0	0	17	0	3	0	0	239	15	0	11	75	348	688	16.8	645	15.7	25.3	1038
2013																	139						
2014																	70						
2015																	70						
2016																	70						
2017																	70						
2018																	70						
Total Present Value																		3287		2302			2913

OPTIMISTIC CASE

Year	Capital Additions	Total Plant Year End	Ann. Depreciation	Accumulated Depreciation	Net Plant Year-End	Deferred Tax	Materials	Fuel	Avg. Rate Base	Return on Rate Base	Income Tax	Depreciation	Insurance	Local Tax	Decommissioning	Fuel	O&M	PILGRIM TOTAL Annual Costs	PILGRIM TOTAL Cost in Cents per kwh	PILGRIM TOTAL Incremental (mil.)	PILGRIM TOTAL Cost in Cents per kwh	QFs Cost in Cents per kwh	QFs Annual Cost (mil.)
	(in millions of dollars)																						
1987	150	846	24	176	670	-104	20	51	562	58	27	24	5	11	4	1	97	226	6.1	8	0.2	3.3	30
1988	45	891	28	204	687	-113	21	51	624	64	30	28	5	11	5	24	99	266	7.2	98	2.7	3.5	130
1989	50	941	30	234	707	-122	22	50	633	65	31	30	5	11	5	21	107	275	7.4	134	3.6	3.6	135
1990	70	1011	32	266	745	-130	23	50	653	67	32	32	5	12	5	21	120	295	7.9	160	4.3	3.7	138
1991	60	1071	35	301	770	-139	24	50	675	70	33	35	6	12	5	21	125	308	8.3	179	4.8	4.2	157
1992	66	1137	38	339	798	-145	26	50	695	72	34	38	6	13	6	21	131	321	8.6	199	5.4	5.7	210
1993	69	1206	42	381	825	-150	27	54	722	75	33	42	6	13	6	23	138	338	9.1	220	5.9	6.1	227
1994	73	1279	45	426	853	-150	28	56	751	78	37	45	6	14	7	24	145	355	9.6	263	7.1	6.6	246
1995	76	1356	49	476	880	-148	30	60	783	81	38	49	7	14	7	26	152	374	10.1	285	7.7	7.2	266
1996	80	1436	54	530	906	-147	31	66	816	84	40	54	7	15	7	28	161	396	10.7	310	8.4	7.6	229
1997	84	1520	59	589	931	-145	33	67	843	87	41	59	7	15	8	29	172	418	11.3	334	9.0	8.5	316
1998	89	1609	65	654	954	-144	34	75	876	91	43	65	8	15	8	32	183	445	12.0	364	9.8	9.2	342
1999	93	1702	71	726	976	-142	36	75	899	93	44	71	8	15	9	32	195	468	12.6	390	10.5	10.2	377
2000	98	1799	79	805	995	-139	38	84	929	96	45	79	9	16	9	36	208	498	13.4	422	11.4	11.1	412
2001	102	1902	87	892	1010	-136	40	84	947	98	46	87	9	16	10	36	222	524	14.1	451	12.2	12.0	443
2002	108	2009	97	988	1021	-130	42	92	971	100	47	97	9	16	11	40	236	556	15.0	485	13.1	13.2	483
2003	113	2122	108	1096	1026	-120	44	94	987	102	48	108	10	16	11	40	251	586	15.8	517	14.0	13.9	517
2004	119	2241	121	1217	1024	-108	46	99	1002	104	49	121	10	16	12	43	267	622	16.8	555	15.0	15.1	561
2005	125	2366	136	1353	1013	-91	48	105	1013	105	50	136	11	15	13	45	284	659	17.8	593	16.0	16.5	511
2006	131	2496	154	1507	990	-68	51	111	1018	105	50	154	11	15	14	48	303	700	18.9	637	17.2	17.8	659
2007	137	2634	176	1683	951	-39	53	118	1014	105	50	176	12	14	15	51	322	745	20.1	683	18.4	18.6	691
2008	110	2744	201	1884	859	-2	43	125	970	100	47	201	13	13	16	54	343	786	21.2	726	19.6	19.9	740
2009	88	2831	226	2110	721	44	34	94	849	88	42	226	13	11	17	57	365	818	22.1	760	20.5	21.2	786
2010	70	2902	252	2362	540	101	27	62	695	72	34	252	14	8	19	60	389	848	22.9	790	21.3	22.5	833
2011	56	2958	284	2646	312	171	22	31	508	53	25	284	15	5	21	64	414	879	23.7	822	22.2	23.8	883
2012	45	3003	357	3003	0	263	17	0	257	27	13	357	15	0	11	68	440	930	25.1	886	23.9	25.3	937
2013																	176						
2014																	88						
2015																	88						
2016																	88						
2017																	88						
2018																	88						
Total Present Value																		3608		2679			2629

ANNUAL COSTS OF PILGRIM VS. ALTERNATIVES

NATIONAL TREND CASE

Year	Capital Additions	Total Plant Year End	Ann. Depreciation	Accumulated Depreciation	Net Plant Year-End	Deferred Tax	Materials	Fuel	Avg. Rate Base	Return on Rate Base	Income Tax	Depreciation	Insurance	Local Tax	Decommissioning	Fuel	O&M	PILGRIM TOTAL: Annual Costs	PILGRIM TOTAL: Cost in Cents per kwh	PILGRIM TOTAL: Incremental (mil.)	PILGRIM TOTAL: Cost in Cents per kwh	GFs: Cost in Cents per kwh	GFs: Annual Cost (mil.)
	(in millions of dollars)																						
1987	150	846	24	176	670	-104	20	51	562	58	27	24	5	11	4	1	97	226	6.9	8	0.2	3.3	27
1988	62	908	28	204	704	-113	21	51	632	65	31	28	5	11	5	22	99	265	8.1	97	3.0	3.4	113
1989	68	976	31	235	741	-123	22	50	657	68	32	31	5	12	5	19	107	278	8.5	137	4.2	3.6	117
1990	75	1051	34	269	782	-132	23	50	686	71	34	34	5	12	5	19	120	299	9.1	165	5.0	3.6	119
1991	82	1133	37	306	827	-141	24	50	719	74	35	37	6	13	5	19	125	315	9.6	187	5.7	4.2	136
1992	90	1223	42	348	875	-148	26	50	758	78	37	42	6	14	6	19	131	332	10.1	210	6.4	5.7	186
1993	94	1318	46	394	923	-155	27	54	803	83	39	46	6	14	6	21	138	353	10.8	236	7.2	6.1	200
1994	99	1417	51	445	971	-156	28	56	850	88	42	51	6	15	7	21	145	375	11.4	283	8.6	6.5	215
1995	104	1521	57	502	1019	-157	30	60	900	93	44	57	7	16	7	23	152	398	12.1	309	9.4	7.0	230
1996	109	1630	63	565	1065	-157	31	66	951	98	46	63	7	17	7	25	161	425	12.9	339	10.3	7.5	248
1997	115	1745	70	635	1109	-157	33	67	995	103	49	70	7	17	8	26	174	454	13.8	370	11.3	8.2	268
1998	121	1865	78	713	1152	-157	34	75	1044	108	51	78	8	18	8	29	188	488	14.8	407	12.4	8.7	288
1999	127	1992	87	800	1192	-157	36	75	1083	112	53	87	8	18	9	29	204	519	15.8	441	13.4	9.6	314
2000	133	2125	97	897	1228	-156	38	84	1127	117	55	97	9	19	9	32	219	557	16.9	481	14.6	10.3	340
2001	139	2264	108	1005	1259	-154	40	84	1159	120	57	108	9	20	10	32	236	591	18.0	518	15.8	11.0	362
2002	146	2411	121	1126	1284	-149	42	92	1196	124	58	121	9	19	11	35	254	631	19.2	560	17.0	12.0	394
2003	154	2564	136	1262	1302	-139	44	94	1224	126	60	136	10	20	11	36	272	671	20.4	602	18.3	12.7	417
2004	161	2726	154	1416	1310	-125	46	99	1249	129	61	154	10	20	12	38	292	716	21.8	649	19.8	13.6	448
2005	170	2896	174	1590	1305	-106	48	105	1267	131	62	174	11	19	13	40	313	763	23.2	698	21.2	14.7	484
2006	178	3074	199	1790	1284	-80	51	111	1277	132	62	199	11	19	14	42	336	816	24.8	753	22.9	15.8	519
2007	187	3261	230	2019	1241	-44	53	118	1275	132	62	230	12	18	15	45	359	873	26.5	811	24.7	16.5	541
2008	150	3410	263	2282	1128	2	43	125	1223	126	60	263	13	16	16	47	385	926	28.2	866	26.3	17.6	578
2009	120	3530	297	2579	950	61	34	94	1080	112	53	297	[illegible]	14	17	50	411	967	29.4	909	27.6	18.6	612
2010	96	3625	333	2912	713	135	27	62	890	92	44	333	14	11	19	53	440	1004	30.6	947	28.8	19.7	648
2011	77	3702	376	3288	414	227	22	31	655	68	32	376	15	6	21	56	470	1043	31.7	986	30.0	20.9	688
2012	61	3763	475	3763	0	346	17	0	333	34	16	475	15	0	11	60	501	1113	33.9*	1069	32.5	22.2	731
2013																	201						
2014																	100						
2015																	100						
2016																	100						
2017																	100						
2018																	100						
Total Present Value																		3928		2998			2185

PILGRIM TREND CASE

Year	Capital Additions	Total Plant Year End	Ann. Depreciation	Accumulated Depreciation	Net Plant Year-End	Deferred Tax	Materials	Fuel	Avg. Rate Base	Return on Rate Base	Income Tax	Depreciation	Insurance	Local Tax	Decommissioning	Fuel	O&M	PILGRIM TOTAL: Annual Costs	PILGRIM TOTAL: Cost in Cents per kwh	PILGRIM TOTAL: Incremental (mil.)	PILGRIM TOTAL: Cost in Cents per kwh	GFs: Cost in Cents per kwh	GFs: Annual Cost (mil.
	(in millions of dollars)																						
1987	150	846	24	176	670	-104	20	51	562	58	27	24	5	11	4	1	97	226	7.7	8	0.3	3.3	24
1988	66	912	28	205	708	-113	21	51	634	65	31	28	5	11	5	19	99	263	9.0	95	3.3	3.3	98
1989	73	985	31	236	750	-123	22	50	663	69	32	31	5	12	5	17	107	277	9.4	136	4.6	3.5	102
1990	80	1066	34	270	796	-132	23	50	697	72	34	34	5	13	5	17	120	300	10.2	165	5.6	3.4	104
1991	88	1154	38	308	846	-142	24	50	734	76	36	38	6	13	5	17	125	316	10.8	188	6.4	4.0	118
1992	97	1251	43	351	900	-149	26	50	778	80	38	43	6	14	6	17	131	335	11.4	213	7.2	5.7	167
1993	106	1356	48	398	958	-156	27	54	830	86	41	48	6	15	6	18	138	357	12.2	240	8.2	6.0	177
1994	116	1472	53	452	1020	-159	28	56	888	92	43	53	6	16	7	19	146	382	13.0	290	9.9	6.4	187
1995	126	1598	60	512	1086	-160	30	60	953	99	47	60	7	17	7	20	159	415	14.2	326	11.1	6.8	199
1996	138	1736	68	580	1156	-161	31	66	1024	106	50	68	7	18	7	22	173	452	15.4	366	12.5	7.2	210
1997	150	1886	77	657	1229	-162	33	67	1092	113	53	77	7	19	8	23	189	489	16.7	405	13.8	7.6	223
1998	157	2043	87	744	1299	-164	34	75	1167	121	57	87	8	20	8	26	205	532	18.1	451	15.4	8.0	236
1999	165	2209	99	843	1366	-165	36	75	1230	127	60	99	8	21	9	26	223	572	19.5	494	16.8	8.5	250
2000	174	2382	112	954	1428	-165	38	84	1298	134	63	112	9	22	9	29	241	619	21.1	543	18.5	9.1	269
2001	182	2565	127	1081	1484	-164	40	84	1352	140	66	127	9	23	10	29	260	663	22.6	590	20.1	9.5	28[illegible]
2002	191	2756	144	1225	1532	-160	42	92	1410	146	69	144	9	23	11	31	280	713	24.3	642	21.9	10.1	297
2003	201	2957	163	1388	1569	-150	44	94	1457	151	71	163	10	23	11	32	302	763	26.0	695	23.7	10.7	314
2004	211	3168	186	1574	1594	-135	46	99	1499	155	73	186	10	24	12	34	325	819	27.9	753	25.6	11.3	332
2005	222	3390	213	1787	1603	-113	48	105	1532	158	75	213	11	23	13	36	349	878	29.9	813	27.7	12.0	352
2006	233	3623	246	2033	1590	-83	51	111	1553	161	76	246	11	23	14	38	375	944	32.2	881	30.0	12.7	373
2007	244	3867	285	2318	1549	-41	53	118	1557	161	76	285	12	22	15	40	403	1014	34.6	952	32.5	13.1	384
2008	195	4062	329	2647	1415	15	43	125	1500	155	73	329	13	19	16	42	432	1080	36.8	1020	34.8	13.9	407
2009	156	4219	373	3021	1198	88	34	94	1335	138	65	373	13	17	17	45	463	1133	38.6	1074	36.6	14.6	429
2010	125	4344	420	3441	903	178	27	62	1108	115	54	420	14	13	19	48	496	1179	40.2	1121	38.2	15.5	455
2011	100	4444	476	3917	527	292	22	31	822	85	40	476	15	7	21	50	531	1226	41.8	1169	39.8	16.5	483
2012	80	4524	607	4524	0	444	17	0	421	44	21	607	15	0	11	54	568	1318	44.9	1274	43.4	17.5	512
2013																	227						
2014																	114						
2015																	114						
2016																	114						
2017																	114						
2018																	114						
Total Present Worth																		4236		3306			1750

Notes to Appendix A

Assumptions and Methods

Capital Additions:

BECO: Escalation of approximately .5 percent per year, after adjusting for inflation, from about $30 million per year (1986 constant dollars). Declines by 23 percent a year over last five years of plant's life.

Optimistic: Linear growth at $2.5 million per year for five years to approximately $50 million per year (1986 dollars), followed by same escalation and decline as BECO. Derived from linear regression of Pilgrim historical experience between 1973 and 1976, treating the four years with expenditures significantly above the trend line as one-time expenditures which will not recur.

National Trend: Linear growth at $3.2 million per year for five years to $69 million per year (1986 $), followed by same pattern as BECO. Derived from ESRG multi-variate regression equation applied to Pilgrim.

Pilgrim Trend:

Linear growth at $3.5 million per year for 10 years to $92 million per year year (1986$), followed by same pattern as BECO. Derived from linear regression, excluding two largest outliers.

Plant-in-Service Year End:

Calculated as in BECO Exhibit 1.

= Capital Additions + Prior Total Plant Year End

Annual Depreciation:

= (Half of Year's Capital Additions + Prior Year Net Plant) / Remaining Life

Deferred Taxes:

Calculated as in BECO Exhibit 2.

Prior Year Accumulated Deferred Taxes + (Tax Rate x (Year's Tax Depreciation - Year's Book Depreciation))

Year's Tax Depreciation calculated as in BECO Exhibit 2 (150% Double Declining Balance).

Materials & Supplies:

From BECO Exhibit 1.

Nuclear Fuel in Rate Base:

From BECO Exhibit 1.

Average Rate Base:

Calculated as in BECO Exhibit 1.

= Net plant Year End + Deferred Taxes + Materials & Supplies + Nuclear Fuel in Rate Base - Half of Year's Capital Additions

Return on Rate Base:

Calculated as in BECO Exhibit 1.

= Average Rate Base x 10.338%

Income Taxes:
Calculated as in BECO Exhibit 1.

= Average Rate Base x 4.89%

Insurance
From BECO Exhibit 1.

Local Taxes
Calculated as in BECO Exhibit 1.

= Average Rate Base x 1.8%

Decommissioning contribution:
F. om BECO Exhibit 1.

Sinking fund to accumulate $126 million (1986$) by 2012.

Fuel:
Calculated from BECO Exhibit 1.

BECO's annual fuel estimate adjusted by ratio of assumed capacity factor to BECO's assumed capacity factor of 70%.

O&M Costs:
BECO: 0.5% per year from 1990

Optimistic: 2% real growth from year when BECO projection crosses National Trend line.

National Trend: Same as BECO to 1990. Linear growth of $3.6 million per year thereafter (1986$); derived from ESRG equation applied to Pilgrim characteristics.

Pessimistic:

Same as BECO to 1990. Then linear growth of $4.4 million per year (1986$) per year derived from linear regression of Pilgrim historical O&M costs from 1973 to 1986.

Present value of O&M shutdown costs is included in present value of year 2012 O&M. Year 2013 O&M is assumed to be 40% of prior year; 20% for the five years thereafter. Based on BECO Exhibit 2.

Annual Costs:
= Return + Income Tax + Depreciation + Insurance + Local Tax + Decommissioning + Fuel + O&M

Costs in Cents per Kwh:
= Annual Cost / Annual Generation

Annual Generation = Capacity [670000 Kw] x 8760 hours/yr. x Capacity Factor

Capacity Factor:
BECO: 70%

Optimistic:

Average of seven BWRs between 400 - 799 Mw for 1977-1986

= 63.159%

From North American Electric Reliability Council. Equipment Availability Report 1975 - 1986.

National Trend:

56 percent; derived from ESRG regression equation for Pilgrim and equal to Pilgrim's lifetime capacity factor before its shutdown in April, 1986.

Pilgrim Trend:

50 percent; Pilgrim's lifetime capacity factor as of October 1987.

Incremental Costs:

Incremental cost comparison is BECO's preferred way of comparing future Pilgrim costs with alternatives. Comparing Pilgrim incremental costs (which subtract shutdown and sunk cost charges from Pilgrim total costs) to alternative costs is the same as comparing Pilgrim total costs to alternative costs plus shutdown and sunk cost charges.

As in BECO Exhibit 2

= Annual Cost - Cost of service on sunk costs

Cost of service on sunk costs includes return and depreciation (amortization) on sunk costs as of end of 1987 (846 million); plus O&M costs of $40 million in 1988 and $20 million per year in 1989-1993; plus insurance of $2.3 million per year 1988-1993; plus property taxes declining from $9 million in 1988 to $1 million in 1993 and thereafter; plus decommissioning. In BECO Case, $50 million in nuclear fuel and $20 million in materials and supplies is included in sunk cost rate base. In MASSPIRG scenarios, it is assumed that 64% of the investment in fuel and supplies is sold to other utilities, and 36% included in rate base.

Replacement Power Costs:

Pilgrim Trend Case:

= Average Award Group Bid; from John Whippen, Manager, Energy Resource Planning & Forecasting, Boston Edison, Letter to RFP Respondents, October 13, 1987.

National Trend Case:

= Estimated average bid from next 764 Mw supply block after Award Group.

= RFP Ceiling Price - ((RFP Ceiling Price - Average Award Group Bid)

x ((Average Supply Block Ratepayer Benefit Score - 1) / (Average Award Group Ratepayer Benefit Score - 1)))

The average Ratepayer Benefit Score of the Award Group was 1.31; the average Ratepayer Benefit Score of the next 764 Mw supply block was 1.22. Each year, the supply block price was assumed to capture 22/31 of the benefits of the award group, or 70.9% of the difference between the ceiling price and the Award Group.

RFP Ceiling Price from John Whippen, Letter to RFP Recipient, February 19, 1987.

Ratepayer Benefit Scores from Frank McCall, Letter, October , 1987.

Pilgrim Trend Case:

= Estimated average bid of the entire 1327 Mw of acceptable QFs not in the Award Group. Calculated as above. Average savings = 52.4% of Award Group.

Present Value:

The calculation of present value of a future cash stream discounts future cash flows to reflect the time value of money. A dollar in hand today is worth more than a dollar next year, by the amount of interest that could be earned (or the interest payments that could be deferred) by having the dollar for the year's time.

Discount rate = 10.55%, from BECO Exhibit 1.

Appendix B

MASSPIRG NUCLEAR COST ESTIMATES

A. Capital additions

Nuclear plants have required steadily increasing capital additions in order to replace worn-out parts and meet new safety standards. On average nuclear capital additions have increased at 13 percent a year since 1970, after adjusting for inflation (Figure 14). Replacement of some reactor parts, such as cracked pipes in Boiling Water Reactors (BWRs) like Pilgrim, and steam generators in Pressurized Water Reactors (PWRs), have required as much as $100 million or more per plant.

Pilgrim cost trends were analyzed by a statistical technique called "linear regression analysis." An equation was determined for the straight line that best fits Pilgrim's historical cost pattern, after adjusting for the effects of inflation. To measure national cost trends, this report uses equations developed by the Energy Systems Research Group (ESRG), a Boston- based consulting group that has studied nuclear costs for numerous state regulatory and consumer agencies around the country.[23] ESRG has analyzed nuclear cost trends using "multi-variate regression analysis" -- a technique which relates changes in nuclear costs to a number of factors such as plant type, size, location, vintage (in-service date), and year of operation.

In general, plants with Pilgrim's characteristics have experienced far greater capital additions than the national average. BWR capital additions have escalated faster than at PWRs, for instance, and salt-water cooled plants, like Pilgrim, have experienced more capital additions than fresh-water

Figure 14

NATIONAL AVERAGE CAPITAL ADDITIONS

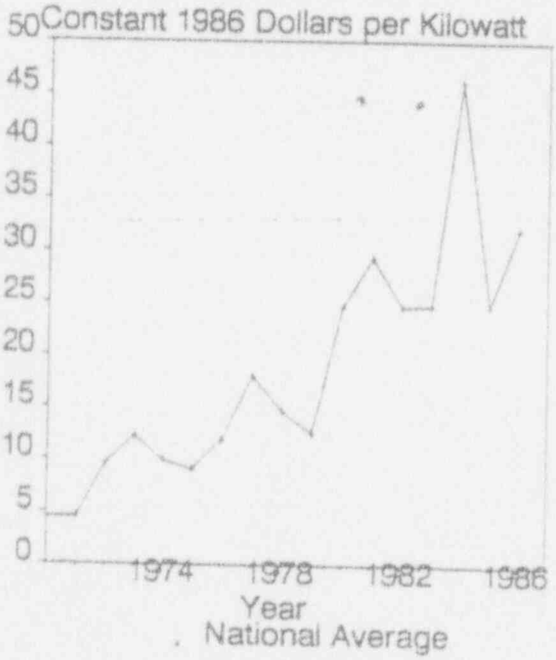


Figure 15

PILGRIM & NAT. AVG. CAPITAL ADDITIONS

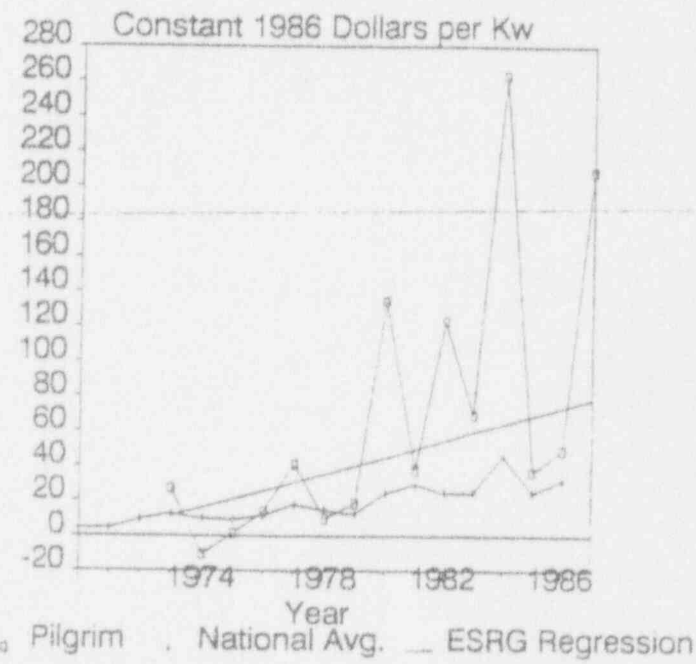
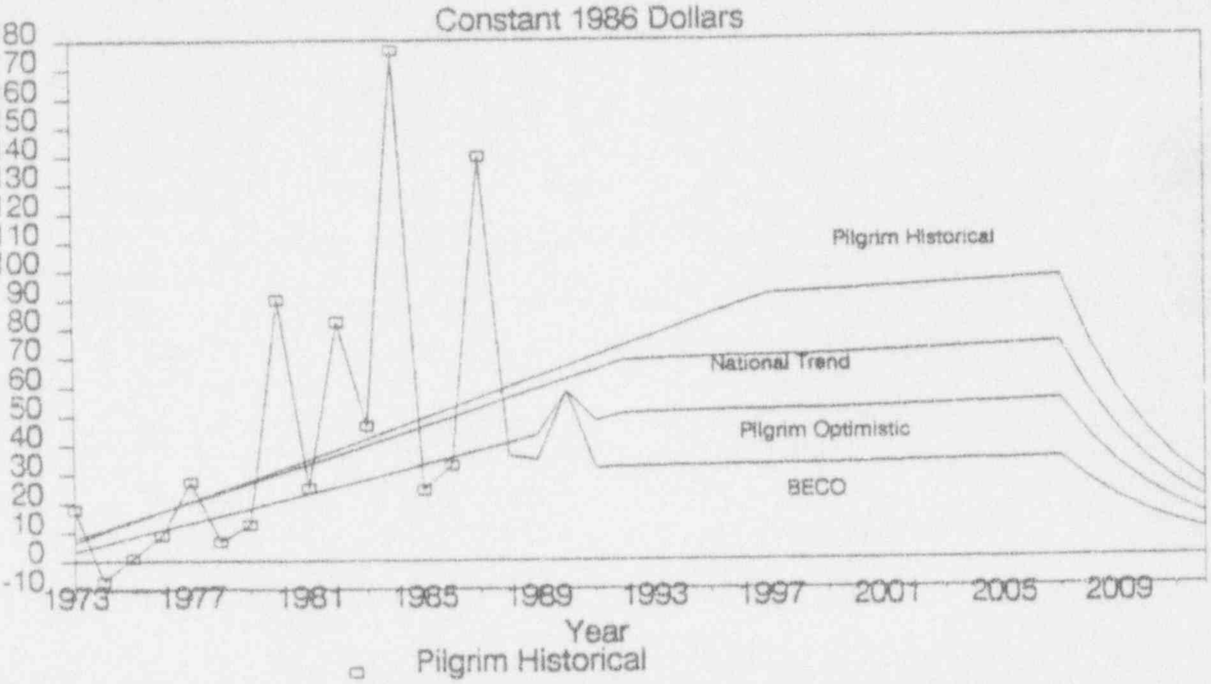


Figure 16

CAPITAL ADDITIONS PROJECTIONS



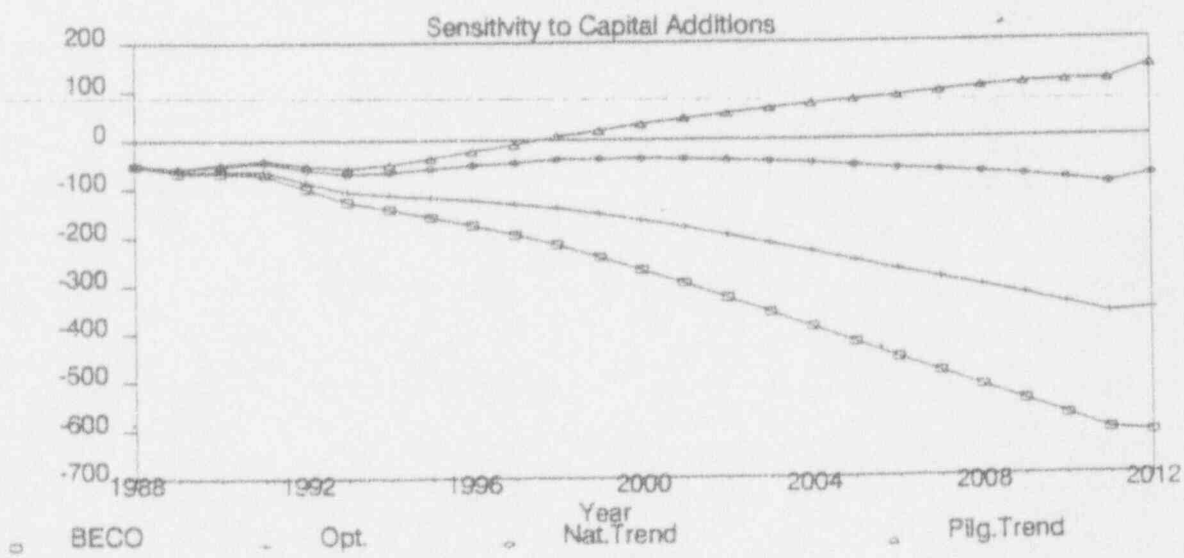
cooled plants. ESRG's regression analysis has found that capital additions are related to plant size, type, cooling water, age, year of initial operation, and whether a plant has one or two units at a site.

Capital additions at the Pilgrim plant have been among the highest of any U.S. nuclear plant. Total Pilgrim capital additions over the period of 1972 to 1986 were 3.3 times the national average per kilowatt, and considerably higher than the regression line for plants of the same characteristics (Figure 15).

Figure 16 displays alternative projections of future Pilgrim capital additions. Except for one moderately

Figure 17

CUMULATIVE SAVINGS FROM RETIRING PILG.



expensive repair planned for 1990. Edison forecasts several years of declining real expenses for capital additions, followed by a steady outlay of less than $30 million a year through the year 2007. Capital additions are estimated to decline by 20 percent per year over the last five years of the plant's life. Even Boston Edison appears to have little confidence in its capital additions estimates, however:

> We have provided a reasonable estimate of Pilgrim's costs for the next 25 years. However, as you know, many factors external to the company, such as NRC mandated modifications, can significantly impact Pilgrim's costs.[24]

MASSPIRG's optimistic projection of Pilgrim capital additions starts with the assumption that the four years with the highest capital additions (1980, 1982, 1984, 1987) were caused by unique events – such as the replacement of cracked recirculation pipes in 1984 – which will not recur. The remaining years still show a consistent underlying pattern of capital additions increases which is likely to persist into the future. To be ultra- conservative, the Optimistic Case here assumes that this trend continues only for another five years. Capital additions are also conservatively assumed to decrease over the last five years of the plant's life, even though other utilities have testified that a higher rate of capital additions may be needed to keep them running. (See Appendix B.) Edison's estimate for 1990 capital additions is assumed to represent a particular planned expenditure which is included in MASSPIRG's Optimistic Case as well.

The National Trend Case assumes that Pilgrim's rate of capital additions declines to the level described by the ESRG regression equation, and continues at that rate for five years. The Pilgrim Trend case assumes that capital additions continue at their historic rate (with 1984 and 1987 additions still defined as nonrecurring costs) for 10 years.

Figure 17 illustrates the effect of changing only the assumption about future capital additions, holding all other BECO assumptions the same. If Pilgrim capital additions were to follow the National Trend (an improvement from the historical performance of the plant), it would cost ratepayers very little to retire the plant, even assuming full payment of Pilgrim sunk costs, including a profit.

B. Operation and maintenance costs

Like nuclear capital additions, operation and maintenance (O&M) costs have also been increasing over time, at an average rate of 11.4 percent a year for the nuclear industry as a whole. At Pilgrim, total O&M costs have in-

Figure 18

PILGRIM VS. NATIONAL AVG. O&M COSTS

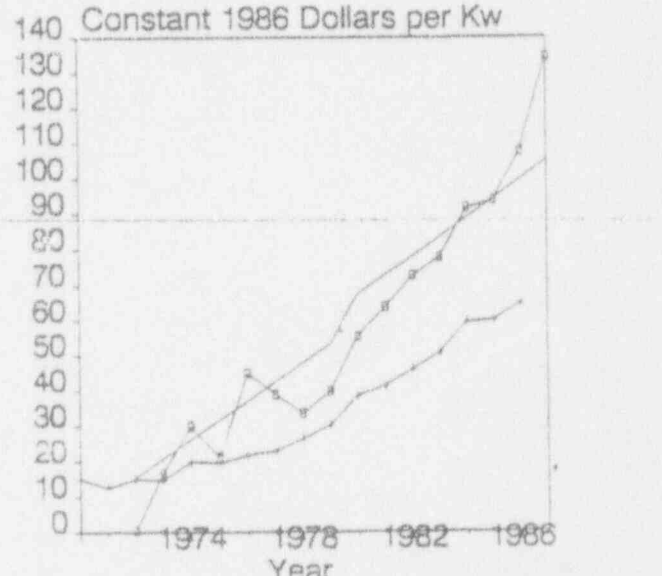
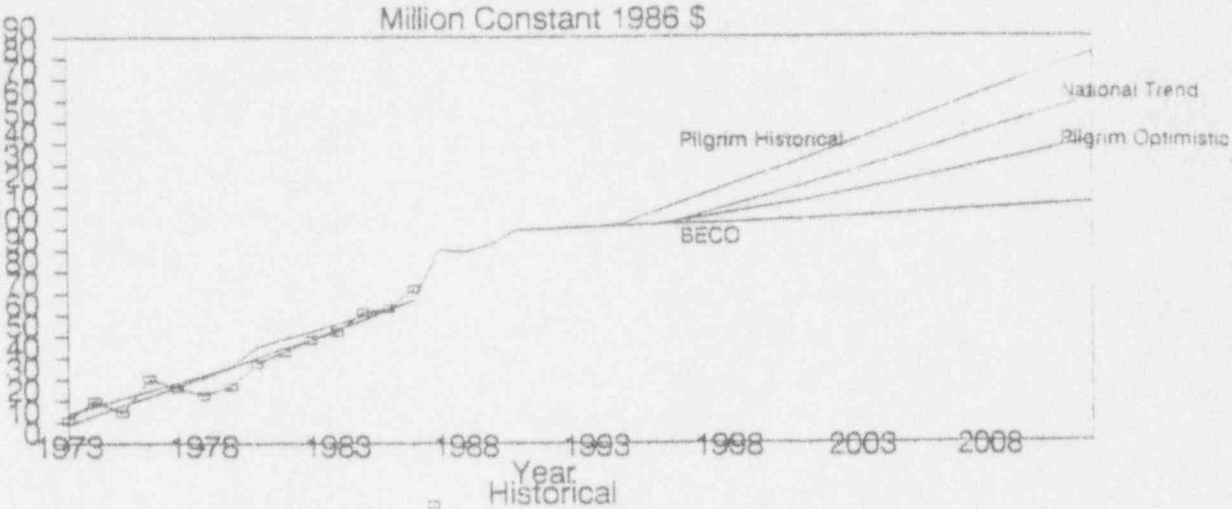


Figure 19

O&M COST PROJECTIONS

Million Constant 1986 $



creased at an annual rate of 13.8 percent, after inflation. Total Pilgrim O&M expenditures between 1972 and 1986 have exceeded the national average per kilowatt by 78 percent. Pilgrim O&M expenses were *less* than the regression line for plants with Pilgrim's characteristics until 1983, however (Figure 18). Figure 18 suggests that management decisions to defer maintenance in the early years of Pilgrim operation may have contributed to some of the plant's later problems.

Not surprisingly, O&M cost increases are correlated with many of the same variables as capital additions -- plant size, age, number of units at a site, and salt-water cooling. After the Three Mile Island Accident in 1979, O&M costs increased at all plants by an average of $8.55 per kilowatt. In addition, plants located in the northeast have had O&M costs averaging about $8 per kilowatt above plants in other regions.

Figure 20

CUMULATIVE SAVINGS FROM RETIRING PILG.

Sensitivity to O&M Costs

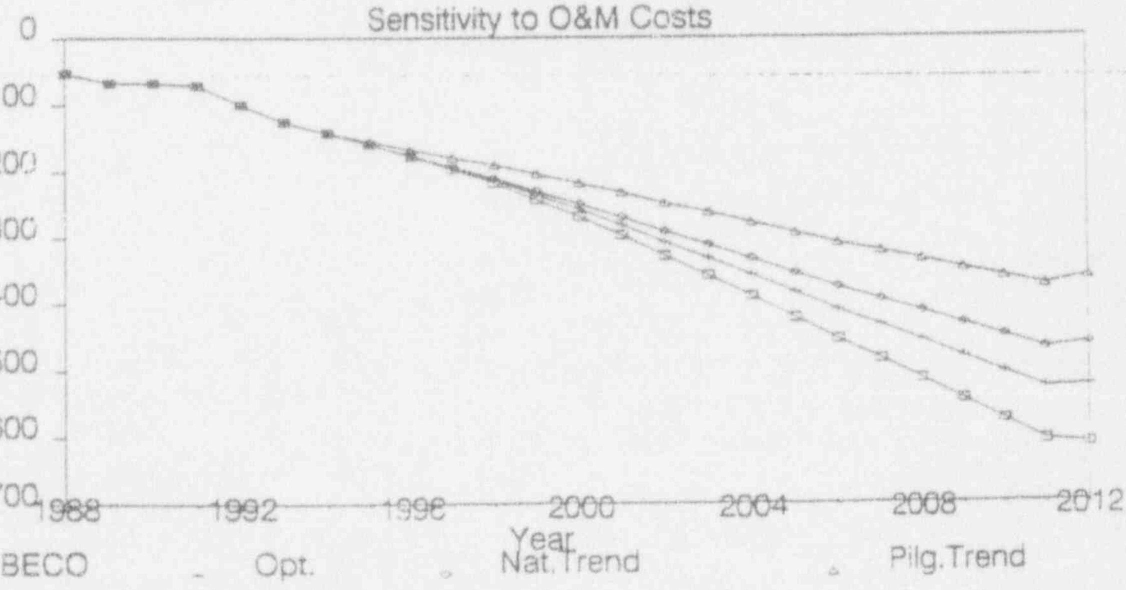
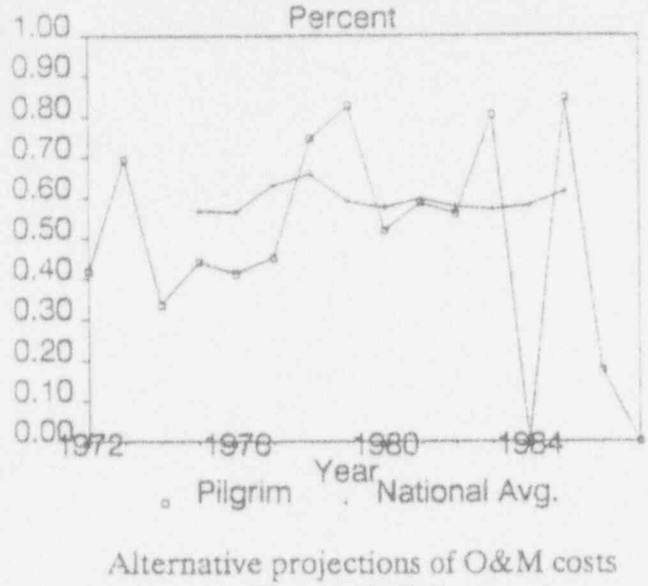


Figure 21

HISTORICAL CAPACITY FACTORS



Alternative projections of O&M costs are shown in Figure 19. Edison projects substantial increases in O&M costs over the next several years, compared to both Pilgrim and national trends. A portion of the near-term O&M costs also includes replacement power costs during extended Pilgrim shutdowns that customers are expected to pay over several years.[25] After 1990, however, BECO projects that real O&M costs, like capital additions, will stabilize in constant dollars, increasing at only 0.5 percent per year.

The MASSPIRG Optimistic Case projects O&M costs increasing at only two percent a year, after adjusting for inflation, after 1994. The National Trend and Pilgrim Trend cases assume that O&M costs eventually resume their historical pattern of increase.

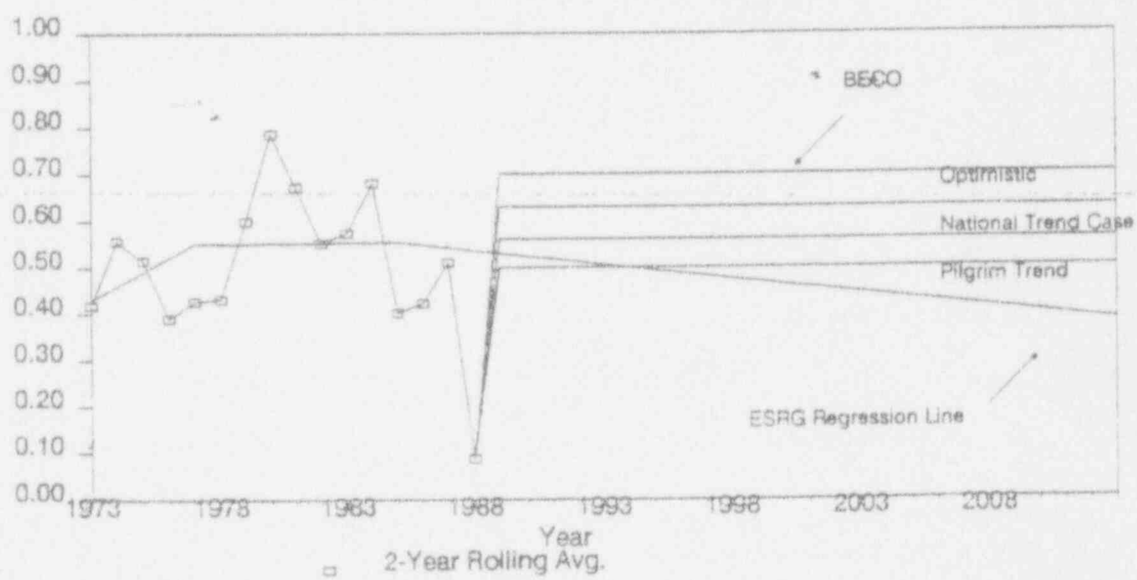
Figure 20 displays the effect of changing only the O&M assumption on cumulative savings from retiring Pilgrim. While significant, the overall impact is not as large as that from changing capital additions assumptions.

C. Capacity factor

The best measure of nuclear plant performance is capacity factor -- roughly, the percentage of time a plant is in-service at full power. The capacity factor of a given plant reflects periods that it is shut down for refueling, maintenance and repair. It also accounts for times when plants may be forced to

Figure 22

CAPACITY FACTOR PROJECTIONS



operate at reduced power levels.

Capacity factors of individual nuclear plants tend to vary a great deal from year to year, particularly since most plants are refueled every other year, and may be taken out of service for several months during that time. Across the entire industry, however, nuclear capacity factors have tended to average consistently just under 60 percent.[26] Pilgrim's lifetime capacity factor to date is only 50 percent. At the point it was shut down in April, 1986, the plant had averaged a capacity factor of 56 percent (Figure 21).

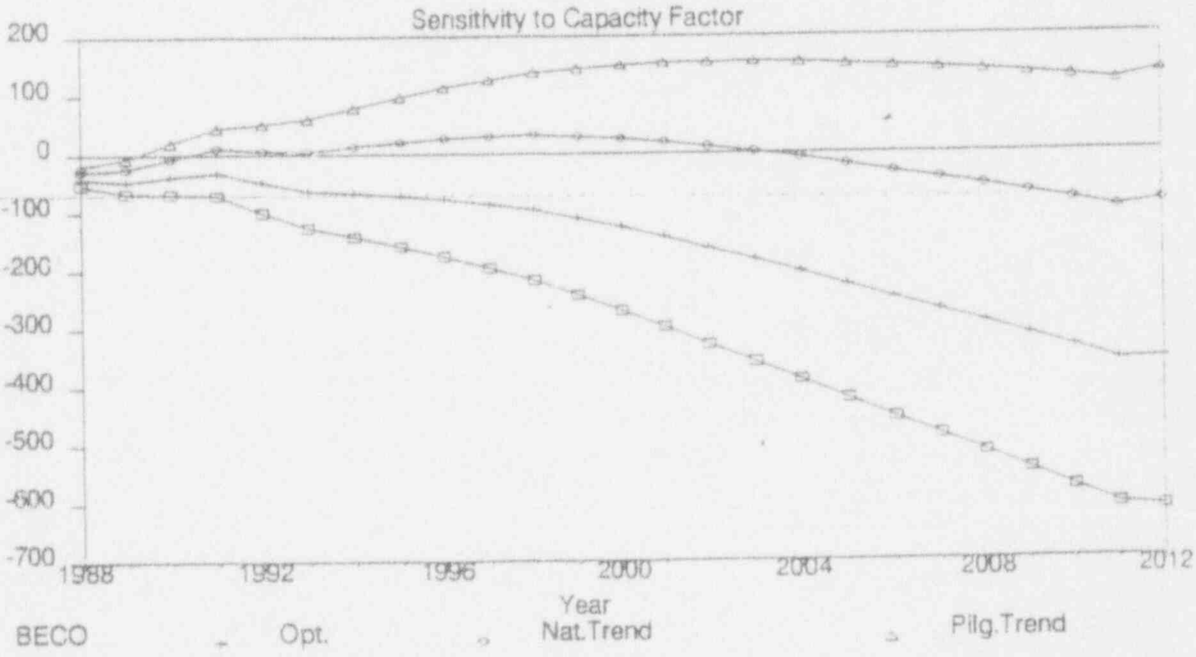
Some varieties of nuclear plants have averaged better performance than others. Between 1975 and 1985, for example, Pressurized Water Reactors (PWRs) averaged capacity factors of 60.8 percent, compared to only 56.6 percent for Boiling Water Reactors (BWRs) like Pilgrim. Smaller plants, however, have generally achieved higher capacity factors than larger plants. Capacity factors of BWRs between 400 Mw and 799 Mw, excluding the Pilgrim plant, averaged 63.2 percent between 1976 and 1986.[27]

ESRG's regression analysis describes capacity factor as a function of plant size, general type, type of cooling water and steam system, and plant age. It shows that nuclear plants have generally tended to increase capacity factors over their first four years of operation, and experience only slight gains in performance over the subsequent eight years. Reactors that are cooled with salt water, like Pilgrim, have tended to decline in performance each year.

Figure 22 illustrates ESRG's regression equation forecast for a plant of Pilgrim's characteristics, and the capacity factor projections used in the three alternative Pilgrim cost scenarios. A two-year rolling average of Pilgrim's historical capacity factor is also shown. Averaging each year's capacity factor with the previous year's helps to smooth out the year-to-year ups and

Figure 23

CUMULATIVE SAVINGS FROM RETIRING PILG.



downs in capacity factor caused by refueling shutdowns every other year.

Boston Edison assumes that Pilgrim will operate at a 70 percent capacity factor over the remainder of its life. Pilgrim's lifetime capacity factor of 50 percent ranks 79th among 94 nuclear plants.[28] The probability of Pilgrim moving from the bottom fifth to well above the average capacity factor is quite low, particularly in light of the trend of declining capacity factors in salt-water cooled reactors.

A 63.2 percent capacity factor -- the national average for small BWRs excluding Pilgrim -- is used in MASSPIRG's Optimistic Case. A 56 percent capacity factor -- equal to Pilgrim's performance before the 1986 shutdown and the peak capacity factor predicted by the regression equation -- is used in the National Trend Case. Finally, the Pilgrim Trend case assumes that the plant will continue to average a 50 percent capacity factor over the rest of its life. These estimates all conservatively assume that the declining performance of salt-water cooled reactors shown by ESRG's regression equation will not continue.

Most of the costs of owning and operating a nuclear plant are "fixed costs" which do not vary with how much electricity the plant actually produces in a given year. The total cost of operating Pilgrim over the next 25 years therefore does not vary much with capacity factor. A lower capacity factor means that more energy would have to be purchased to replace Pilgrim, however, and means a higher cost for each Kwh generated by Pilgrim.

Figure 23 illustrates the impact of capacity factor on the economics of retiring Pilgrim. Even if Pilgrim were able to maintain the 56 percent capacity factor it achieved before its April 1986 shutdown, it would save ratepayers money through the year 2003 to retire the plant, even if all other BECO assumptions hold.

Appendix C
Causes of Nuclear Cost Escalation

The continuing existence of the factors that have contributed to past escalation of nuclear capital additions and operations and maintenance costs make it likely that those expenses will continue to escalate at historic rates for the foreseeable future. The forces driving the cost escalation include the persistence of unresolved safety issues, ongoing technical problems that are discovered as the nuclear industry gains more operating experience, and the aging of reactor components. In addition to increasing costs, premature aging problems also cast serious doubt on whether the Pilgrim plant could be operated for a 40-year lifetime, as Boston Edison projects.

1. Unresolved generic safety issues.

The Nuclear Regulatory Commission maintains a list of unresolved safety issues which are generic to nuclear power reactors. As these issues are resolved, they frequently require significant new expenses to implement them.

Before the 1979 accident at Three Mile Island (TMI), the NRC had resolved 20 of 142 issues identified in its 1978 Task Action Plan, according to a 1984 General Accounting Office report.[29] The TMI accident added many new issues to the Commission's list, and postponed action on many of the previously identified problems. By July 1984, the agency had resolved only 208 of 482 total issues identified through that time. Moreover, new issues were being identified at the rate of 11 per year, while the agency's schedule called for the resolution of only 12 total issues per year. As of August, 1987, 163 issues remained on the unresolved issues list.[30]

New generic issues are likely to be discovered as a result of operating experience, particularly as reactors age. The possibility of additional major nuclear accidents also contributes to the likelihood of new regulations. The NRC staff has estimated that the probability of a full core melt accident at a U.S. nuclear plant may be as high as 45 percent during the next 20 years.[31] Other analysts have estimated the probability to be higher.

One unresolved safety problem that is of particular concern to Pilgrim is the strength of the containment shell which is designed to prevent release of radioactive materials to the environment in the event of an accident. An NRC task force has estimated that the probability of failure of the Mark I containment design used Pilgrim and 25 other U.S. plants may be as high as 90 percent in some accident scenarios, compared to a failure probability of about 10 percent with other containment designs.[32]

Another commission task force is currently studying the Mark I problem, but is not expected to make recommendations for more than a year. There is a substantial probability that fixing the Mark I containment problem will impose costs exceeding current BECO estimates.

2. Ongoing technical problems.

There is 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 reduce capacity factor and require new O&M and capital additions expenditures to fix. The number of Licensee Event Reports (LERs) -- which document mishaps at nuclear plants -- has steadily increased. In 1986, there were 2,957 LERs filed with the NRC, approximately the same as the record 2,997 LERs for 1985, and well above the 2,435 LERs reported in 1984.[33] Nuclear plant capacity factors have failed to increase as the nuclear industry predicted they would as plants matured.

3. Aging of reactor components.

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.[34]

As discussed in the text, salt-water cooling systems at reactors located on oceans, such as Pilgrim, have been associated with more corrosion than fresh-water systems. In addition, the Pilgrim plant has been subject to much higher levels of radiation contamination that many other nuclear plants. The average Pilgrim worker was exposed to 1949 rems a year between 1984 and 1986, compared to 645 rems per year at Millstone 1, in Connecticut, a plant the same type and about the same age as Pilgrim.[35]

4. Nuclear plant lifetimes.

In addition to causing increasing costs for replacement of parts and operation and maintenance expenses, reactor aging casts serious doubt on the ability of nuclear plants to operate for the 40 year period assumed by Edison in its evaluation of Pilgrim economics.

Boston Edison's operating license for Pilgrim currently expires in 2008, after 35 years of operation. The utility has recently applied for an extension of its license to the year 2012. No license extensions for any nuclear plants have yet been considered or granted by the NRC, however, and there is no way at this time of predicting whether such extensions will be granted in the future.

Niagara Mohawk Corporation, the chief owner and operator of the Nine Mile Point 1 nuclear plant, requested permission from the New York State Public Service Commission to use a depreciation life of the plant that is five years *shorter* than the plant's operating license:

> Recognizing the regulatory pressures from the Nuclear Regulatory

Commission, relicensing should not be assumed. If it should happen that it is possible to relicense the plant, the capital expenditures required would be of such a magnitude that the unit, for depreciation purposes, should be considered as being new at that time.[36]

Niagara Mohawk's testimony, in addition to contradicting BECO's assumption of relicensing, also contradicts Edison's assumption that capital additions expenditures would not increase in real terms over the entire last 25 years of the plant's projected life, and would decrease at 20 percent per year over the last five years.

To date, no commercial nuclear plant has yet operated for longer than 27 years (Table 4), and a significant number of reactors have been retired with considerably fewer years of operation. (Table 5)

Table 4. OLDEST U.S. OPERATING NUCLEAR REACTORS

Plant	Location	Initial Operation	Age	Capacity
Yankee	Rowe, MA	1960	27	185
Big Rock Point	Charlevoix, MI	1962	25	75
San Onofre 1	San Clemente, CA	1967	20	450
Haddam Neck	Haddam Neck, CT	1967	20	600
Oyster Creek	Forked River, NJ	1969	18	550
Nine Mile Point1	Scriba, NY	1969	18	642
Ginna	Ontario, NY	1969	18	517
Dresden 2	Morris, IL	1970	17	794
Robinson 2	Hartsville, SC	1970	17	769
Point Beach 1	Two Creeks, WI	1970	17	485
Millstone 1	Waterford, CT	1970	17	660

Source: Critical Mass Energy Project;[33] Nuclear Regulatory Commission

Table 5. RETIRED U.S. REACTORS

Plant	Initial Operation	Retirement Year	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

Notes

[1]A federal study estimated subsidies for research and development, mining and fuel enrichment at almost $40 billion by 1981. (Joseph Bowring, "Federal subsidies to Nuclear Power," unpublished report, Office of Economic Analysis, Energy Information Administration, March 1980. Another estimate of construction subsidies to nuclear power plants runs as high as $15.6 billion for the year 1984 alone. (H. Richard Heede, Richard E. Morgan, and Scott Ridley, *The Hidden Costs of Energy: How Taxpayers Subsidize Energy Development*, Center for Renewable Resources, Washington, D.C., October, 1985)

[2]See *Nuclear Waste Fee Adequacy: An Assessment*, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, DOE/RW- 0020, June 1987, pp. 7-10; *Commercial Nuclear Power: Prospects for the United States and the World*, U.S. Department of Energy/Energy Information Administration, DOE/EIA-0438(86, p. 20); "Nuclear Power Plant Decommissioning: Cost Estimation for Power Planning and Ratemaking," Energy Systems Research Group, Boston, July, 1987.

[3]Charles Komanoff, *Power Plant Cost Escalation*, Komanoff Energy Associates, New York, 1981.

[4]David Schlissel, "Trends for Nuclear Capital Additions and O&M Costs," Direct Testimony Before the Public Service Commission of the State of Missouri Appearing for the Office of the Public Counsel, Case No. ER-85-128, Case No. EO-85-185, June 28, 1985.

[5]*Nuclear Plant Cancellations: Causes, Costs and Consequences*, U.S. Department of Energy/Energy Information Administration, DOE/EIA-0392, April 1983.

[6]Schlissel, *op. cit.*

[7] Richard Hellman and Caroline J.C. Hellman, *The Competitive Economics of Nuclear and Coal Power*, Lexington Books: Toronto, 1983.

[8]Richard McCormack, "Whoops!" *Energy Daily*, April 28, 1986, p. 1

[9]Joseph Kriesberg, *Nuclear Power: Too Costly to Continue*, Draft, Critical Mass Energy Project, Washington, D.C., November 1987

[10]*Ibid.*, from U.S. Department of Energy communication.

[11]Schlissel, *op. cit.*

[12]William Blundell, "Doubts Pervade Nuclear Fuel Industry: Utility Pacts Unclear; Uranium Producers Ailing," *The Wall Street Journal*, October 10, 1985; Kennedy Maize, "Domenici s Uranium Bill Would Trim imports to 50 Percent of U.S. Needs," *The Energy Daily*, February 20, 1986.

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

[14]*Final Report of the Boston Edison Review Panel*, March 1987.

[15]*NEPOOL Forecast Report of Capacity, Energy, Loads and Transmission 1987- 2002*, New England Power Pool, West Springfield, MA, April 1, 1987.

[16]Boston Edison, *Request for Proposals from Qualifying Cogeneration and Small Power Production Facilities*, Appendix C, Exhibit 4, p. 18.

[17]NEPOOL, *op. cit.*

[18]*Final Report: Asset Disposal and Contract Settlement Associated With Pilgrim 2 Cancellation*, Boston Edison Company, Report #10, May, 1987.

[19]*Western Massachusetts Electric Company*, D.P.U. 84-25.

[20]*Western Massachusetts Electric Company*, D.P.U. 85-270

[21]*Nuclear Plant Cancellations, op. cit*,

[22]Harvey Salgo, Raymond Czahar, and Paul Raskin. "Proposal of the Executive Office of Energy Resources, D.P.U. 86-36, April 4, 1986.

[23]Equations for this study were taken from the Testimony of Stephen Bernow on "Excess Capacity and Cost Benefit Analysis of Vogtle Generating Station" on behalf of the Georgia Office of Consumers' Utility Counsel before the Georgia Public Service Commission, Docket No. 3673-U, August, 1987.

[24]Carl Gustin, Vice President, Corporate Relations, Boston Edison, Letter to Sharon Pollard, Secretary of Energy Resources, Commonwealth of Massachusetts, June 8, 1987. Also referred to as Exhibit 1. Exhibit 2 is Carl Gustin letter of July 1, 1987..

[25]Gustin, personal communication, October 1987.

[26]ESRG; *Equipment Availability Report 1976-1985*, North American Electric Reliability Council, Princeton, NJ.

[27]*Ibid.*

[28]From Monthly Operating Reports filed with the U.S. Nuclear Regulatory Commission, courtesy of Stephanie Murphy, Nuclear Information and Resource Service, Washington, D.C.

[29]"Management Weaknesses Affect Nuclear Regulatory Commission Efforts to Address Safety Issues Common to Nuclear Power Plants," General Accounting Office, GAO/RCED-84-19, September 19, 1984).

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

[31] NRC Testimony to U.S. House of Representatives, Subcommittee on Energy Conservation and Power, April 1986.

[32]Brian Jordan, "Denton Urges Industry to Settle Doubts About Mark I Containment," *Inside N.R.C.*, June 9, 1986, p. 1.

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

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

[35] David Wessel, "Pilgrim and Millstone, Two Nuclear Plants, Have Disparate Fates," *The Wall Street Journal*, July 28, 1987., p. 1.

[36] John S. Ferguson, Prepared testimony on behalf of the Niagara Mohawk Power Corporation in New York Public Service Commission Case #28225, p. 27.