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Economic Analysis of Vermont Yankee Retirement

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April 22, 1988

Revised

February 16, 1989

Presented to Vermont House of Representatives,
Natural Resources Committee
and
Commerce Committee,

February 21, 1989

1. Introduction and Summary

This study assesses the economic viability of shutting down the Vermont Yankee nuclear plant. Our analysis is based on a comparison of the costs of operating Vermont Yankee through 2007, to the costs of replacing Vermont Yankee power.

Section 2 of this report presents the economic comparison between Vermont Yankee and replacement power sources. Under most plausible assumptions, it is uneconomic to continue operating Vermont Yankee. If Vermont Yankee's operation through 2007 were consistent with national experience, it would cost ratepayers $700 million to $1 billion of dollars more than would alternatives.[1] Vermont Yankee has performed better than national averages in the past: if its future performance is comparable to its historical performance, it will cost ratepayers $200 million more than the DPS's projected mix of conventional power supply sources, and $60 million more than replacement of all Vermont Yankee power with Hydro Quebec purchases.[2] Replacing Vermont Yankee

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1. The cumulative cost figures used in this report are present values in 1988 dollars. The total number of dollars paid, including inflation and interest, would be several times as large.

2. The least-cost mix of replacement power supplies would be some combination of existing conventional supplies in the short term, new Hydro Quebec purchases in the long term (when expensive new coal plants would become the conventional supply), and small power producers whenever they can beat the prices of the other options. This mix would be less expensive than either of the replacement power costs we examined, and would save more than $200 million compared to Vermont Yankee

with a utility-sponsored conservation program would increase the savings to over $500 million, even if Vermont Yankee would have been able to continue its historical level of performance. Table 1.1 lists the combinations of assumptions which we analyzed, and compares them to the analysis presented by the Department of Public Service. Sections 1.1 and 2 describe our results in greater detail.

Section 3 describes the historical cost and operating experience of Vermont Yankee and similar plants, and derives projections for the significant determinants of Vermont Yankee's future cost of power. For most input factors, we provide estimates which are based on Vermont Yankee's past experience, as well as estimates which are based on the historical experience of domestic nuclear reactors.

Section 4 discusses the potential range of Vermont power supply situations, over the next 20 years, including the need for capacity, the source of replacement power for Vermont Yankee, and the cost of replacement energy and capacity.

Several of the estimates used in this report are from outside sources. The Vermont Department of Public Service (DPS) published a report in December, 1987 entitled, "Shutdown Assessment of the Vermont Yankee Nuclear Power Facility". This study is referred to throughout this paper as the "DPS Report." The final DPS report, dated December 1988,

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operation.

is not very different in relevant respects. We have also extracted information from a DPS report on "The Development of Rates Pursuant to Public Service Board Rule 4.100" (September 1986), which present the DPS's most recent published estimates of statewide avoided costs. We refer to this study as the "DPS Avoided Cost" report.

1.1. Comparison to DPS Report

Table 1.1 summarizes the results of the five cases evaluated in this report, and of the case evaluated in the DPS Report. The net operating cost estimated by the Vermont Yankee Nuclear Power Corporation (VYCo) in its October 1987 report was not included in this table for three reasons. First, VYCo provides its results as the summation of nominal dollars over time, rather than as the present value of the costs and benefits. Adding up dollars from 1988 to 2007 produces essentially meaningless numbers. Second, VYCo does not present enough detail to allow us to compute a present value result from their assumptions. Third, the DPS Report uses VYCo's assumptions, except for replacement power costs and a portion of the capacity factor calculations.

The "Present Value Net Cost" column of Table 1.1 shows the cost of continued operation of Vermont Yankee, net of the cost of replacing its power. A positive value indicates that Vermont Yankee is uneconomic under the stated assumptions, while a negative value indicates that it costs less to run than to replace, and is economic.

The last column of Table 1.1 presents the number of years, of the 19 years from 1989 to 2007, in which the charges to ratepayers from continued operation of Vermont Yankee are less than its replacement power costs in the same year. This does not indicate that the plant can be economically operated for a period, and then shut down. In some cases, the years in which the plant is economic are distributed between years in which it is not. Even where the economic years are concentrated in the early portion of the period, it is not possible to have the benefits of the early years without paying some of the costs in later years: the costs of capital additions in 1989 and 1990 are not fully recovered until 2007.

In our analyses, the cases which assumed that Vermont Yankee's past performance will continue have lower net costs for continued operation than do the cases which assume Vermont Yankee will perform at the levels indicated by national experience. Vermont Yankee has been a better-than-average plant in terms of capacity factor, operating costs, and retrofitting expenditures (capital additions). It may continue to be better than average, or it may "regress to the mean." Thus, the actual operating characteristics of Vermont Yankee over the remainder of its life are likely to fall between the "National historical" and "Vermont Yankee Historical" levels.

Of the categories of nuclear power plant performance, the most important for this analysis is the level of operation and maintenance (O&M) costs. Nuclear O&M expenses have been rising steadily at about

10% above inflation, since the early 1970s, both before and after the Three Mile Island accident. Although the nuclear industry has repeatedly projected that O&M would stabilize, it has yet to show any signs of doing so. While we assume a continuation of historical trends in O&M costs, VYCo and DPS assume a rapid stabilization, and little real growth. This is an extremely optimistic projection, which has no basis in historical experience.

Similarly, the projections of capacity factor and capital additions used by VYCo and DPS assume striking improvements over historical levels.

In terms of replacement power cost, Vermont Yankee is most nearly economical when it is compared to the projected cost of Hydro Quebec contracts. However, Hydro Quebec purchases do not appear to be economical compared to the avoided costs estimated by DPS in the Avoided Cost report. In any case, as discussed in Sections 2 and 4, we have somewhat overstated the cost of Hydro Quebec power.

Even the avoided cost estimates from DPS may be somewhat higher than the current estimates of replacement power costs from conventional alternatives. The DPS has indicated to us that their more detailed power supply cost calculations for the DPS Report yielded results lower than the avoided cost estimates. In particular, the avoided cost estimates did not include the possibility of any new contracts for power from Hydro Quebec, and instead added more expensive coal capacity. Unfortunately, the DPS was not able to provide detailed documentation of the replacement power costs used in the DPS Report. In addition, some input costs, such as Federal income taxes, have decreased since the time of the DPS Avoided Cost filing.

The replacement power costs for Vermont Yankee could be reduced substantially by a major program of conservation and load management (C&LM). This cost reduction would occur in two ways:

- The first increments of C&LM would be so inexpensive that they should be undertaken regardless of whether Vermont Yankee continues to operate. This C&LM can not really be considered a replacement for Vermont Yankee, since it should occur anyway. However, it would free up relatively inexpensive existing capacity and energy, which could then be used to replace Vermont Yankee.

- Additional C&LM could also be part of the mix of replacement power sources for Vermont Yankee.

Case E illustrates this possibility by assuming that the replacement power is a mix of C&LM and existing baseload sources (e.g., hydro, purchases, wood, coal), at an average cost of 3 cents/kWh in 1987, escalating at the rate of inflation. This is a reasonable ballpark estimate, although the DPS will be in a better position to assess conservation and load management potential following its current proceeding on least-cost planning. Using this C&LM replacement power mix, rather than the conventional sources assumed in DPS's avoided cost estimates, increases the net economic penalty of operating Vermont Yankee by a factor of three.

2. Approach and Results

This section describes the methodology used in evaluating the economic efficiency of Vermont Yankee. The first step in this process is the determination of the framework for the analysis. In essence, we must decide what we are trying to predict. In this report, we have chosen to estimate the future costs of Vermont Yankee and its alternatives to Vermont utilities.

While there are many reasons for the Legislature and ratepayers to be concerned with the total cost of power from Vermont Yankee, including the costs of the existing investment in the plant, decommissioning, and other unavoidable costs, we have examined only the incremental costs of continued operation, and have completely ignored all sunk costs. Those sunk costs must be paid by someone (probably the ratepayers) regardless of whether Vermont Yankee continues to operate.

We have chosen to concentrate on the Vermont utilities for convenience. If Vermont Yankee is clearly economical for Vermont, it will probably be economical to the other owners as well. Conversely, if Vermont Yankee is much more expensive than Vermont's alternatives, it will almost certainly be uneconomical for other New England utilities, which have generally similar alternatives. If the net cost of shutting down Vermont Yankee is zero or negative, there will be no damages to the out-of-state owners, and Vermont should not face any serious problems from the legal challenges threatened by the Vermont Yankee Corporation (VYCo) in its October 1987 "Analysis of H173."

We have treated the Vermont Yankee shutdown issue from the perspective of the state's ratepayers, and have counted all avoidable costs, including property taxes and state income taxes. While it might be argued that these taxes are not costs to Vermont, they reflect costs of doing business in Vermont which apply to most alternative investments. In addition, it would be difficult to subtract out the Vermont-tax related portion of the replacement power costs, which are likely to include construction and employment in the State, for small power producers, cogenerators, utility power plants, and possibly transmission lines. Ignoring these costs for Vermont Yankee would therefore bias the analysis towards continued operation.

Our treatment of some costs has been simplified. For example, if Vermont Yankee were abandoned, its owners would receive a large tax credit immediately, which would normally be used to decrease the net cost of the write-off to ratepayers. We have assumed that the cost recovery for the sunk costs of the plant would not vary between the operation and cancellation cases, thus understating the net cost of continued operation. On the other hand, VYCo assumes that a relatively high level of O&M expenses would continue until 2007, even if the plant were shut down. We find this somewhat implausible at the cost levels VYCo assumes; in any case, the cost of monitoring a retired plant until decommissioning, assuming that process starts in 2007, would be roughly offset by the reduction in the decommissioning cost due to reductions in radiation levels. Similarly, VYCo and DPS assume that capital additions will trail off in the years just before retirement: there is no evidence that this will occur, and the effect on our analyses would be trivial if it did.

We now proceed to the identification of the categories of costs and other parameters which will be included in the analysis, and then to the sources of the estimates.[3]

2.1. Costs and Other Parameters Included in the Analysis

The current analysis uses one or more levels of each of the following parameters:

1. **Capital Additions:** The total cost of almost any power plant rises over time, as additional investments are required to keep it operating efficiently. Although not as large as those of many nuclear power plants, the "capital additions" for Vermont Yankee have been considerable: Vermont Yankee Corporation's total investment in Vermont Yankee was $172 million at the end of 1972, but it had grown to $326 million by the end of 1986.

2. **Non-fuel Operating and Maintenance Expenses:** These are the direct costs of running the plant, such as salaries

3. By "parameters," we mean any of the numbers which contribute to making a plant cost-effective. Most of these parameters are costs, such as construction costs, operating costs, decommissioning costs, and so on, but other important parameters determine how much benefit is derived from the plant. Examples of this category include the plant's rated capacity, its capacity factor, and its useful life.

for plant operators, outside services, and the costs of routine replacement materials (e.g., filters and lubricants). The O&M costs are reported by the operators of each US nuclear power plant to the FERC, and are distinct from the capital additions.

3. **Fuel:** This is examined separately from other O&M costs for two reasons. First, nuclear fuel costs have been quite steady in recent years, while the other O&M costs have been rising rapidly, suggesting that different projection techniques may be appropriate for the two costs. Second, fuel costs vary with the level of plant output, while the other O&M costs increase little (if at all) as plant operation increases.

4. **Rated Capacity:** As for most products, the capacities of nuclear power plants are rated in different ways for different purposes, complicating comparisons between plants. Vermont Yankee has in the past been accredited as having a Design Electrical Rating of 514 MW. We use this figure wherever possible, but we must sometimes convert data from capacities stated in different terms. Throughout much of this report, cost estimates are based on the 55% of Vermont Yankee's capacity owned by (or otherwise committed to) Vermont utilities.

5. **Capacity Factor:** The capacity factor of a power plant is the plant's actual output (in megawatthours) in some time period, divided by its total potential output (the rated capacity times the hours in that period). Vermont Yankee's capacity factor is very important in determining the plant's value in displacing purchases by Vermont utilities from other sources. The higher the capacity factor, the more economical Vermont Yankee will be.

6. **Property Tax:** The property taxes Vermont Yankee Corporation pays to Vermont, Vernon, and Brattleboro are largely determined by the net depreciated cost of the plant.

7. **Overheads:** In addition to the O&M costs reported as station O&M, utilities have expenses related to the ownership of nuclear plants which are not usually assigned to the plant accounts. These expenses include employee benefits (such as pensions), employment taxes, insurance, legal fees, and regulatory expenses. We have estimated these costs (as a fraction of station non-fuel O&M) from the FERC reports of Vermont Yankee Corporation for 1981-1986.

8. **Replacement costs:** If Vermont Yankee does not operate, Vermont utilities must replace its capacity and energy production with new construction, increased use of existing facilities, or purchases of power from other utilities or independent producers. We have used replacement power projections based on the current and pending contracts of New England utilities for power from Hydro Quebec, and an alternative estimate based on the DPS Avoided Cost estimate for purchases from small power producers.

9. **Discount rates:** In order to compare costs over time, it is necessary to discount the value of later costs, to reflect the fact that a dollar now is worth more than a dollar in 5 or 10 years. We use the DPS discount rate of 10.5% for this comparison.

10. **Inflation rates:** We use the DPS GNP inflation rate projections, from the Avoided Cost report.

2.2. Sources of the Parameter Values

For most cost parameters, we have calculated projections based on the past experience of Vermont Yankee (VT. YANKEE) and historical trends of national nuclear power plants (NATIONAL). Sources of each of the parameters are as follows:

1. **Capacity Factors**

   - VT YANKEE: Vermont Yankee mature capacity factor, from its fifth year (starting January 1978) to December, 1987 (the most recent data available from the NRC).

   - NATIONAL: The projection for a unit of Vermont Yankee size and age, from a regression on national BWR capacity factors through 1986, with performance assumed to continue at levels typical of the 1980s.

2. O&M

   - VT YANKEE: Continuation of Vermont Yankee historical straight-line trend.

- NATIONAL: Projection based on a regression of national data, scaled for Vermont Yankee characteristics.

3. **Capital Additions**

- VT YANKEE: Average Vermont Yankee additions 1980-86, in constant dollars.

- NATIONAL: Projection based on national data, evaluated for Vermont Yankee characteristics, and 1980s conditions.

4. **Overheads**

- Each case: Assume that the ratio of overheads to non-fuel station O&M 22.8%, a value typical of Vermont Yankee experience from 1981-1986.

5. **Replacement Energy Source**

- HQ: Replacement power costs are equal to recent sales offered by Hydro Quebec.

- DPS: Replacement power costs are based on the DPS's calculation of avoided costs due to purchases of power from small power producers. This represents the cost of additional supplies from the utilities' alternative sources.

- C&LM: Replacement power is from conservation, load management, and existing sources freed up by those efficiency improvements. The cost is assumed to be 3 cents/kWh in 1987, rising at the general inflation rate.

6. **Discount rates**

- Each case: DPS's 10.5%.

7. **Useful Life**

- Each case: Vermont Yankee operates through 2007, its 35th year.

In order to determine the economic value of Vermont Yankee, we must compare the cumulative net present value of the cost components to the cumulative net present value of alternative power. Tables 2.1.A - 2.1.E show such comparisons, for various assumptions regarding Vermont Yankee cost projections and replacement power cost projections.

Lines 1-13 of each table show the derivation of the capital cost recovery, reduced to the percentage allocated to Vermont utilities (55%). While 1990 capital additions (for example) can not be avoided by a shutdown in 1995, the ratemaking process spreads the recovery of the capital costs over the remaining life of the plant. Lines 14-16 display other non-fuel Vermont Yankee cost components, which are also scaled down to 55% of the plant. Line 17 is the total of these cost components, which include depreciation, return on rate base, income taxes, property taxes, Vermont use tax, operations and maintenance expense, and overhead expense. Line 18 shows the capacity factor, and line 19 displays the calculation of the fuel expense, while line 20 shows the total cost associated with Vermont Yankee. Lines 21 and 22 provide the cost of replacing Vermont Yankee either with purchases from Hydro Quebec or with purchases from small power producers. Line 23 shows the difference between the cost of operating Vermont Yankee and the cost of replacing the nuclear plant. A positive value indicates that Vermont Yankee will be more expensive than the alternatives, while a negative value indicates that Vermont Yankee will be less expensive in that year.

Lines 24 and 25 restate the Vermont Yankee and replacement costs on a $/MWH basis (which is ten times the cent/kWh cost), which is easier to relate to common experience than are millions of dollars for a share of the plant. Finally, Line 26 presents the cumulative present value of the net cost, which is a measure of whether the plant will be a good deal from 1988 to the year listed. The last column of each table shows the cumulative present value of each cost component through 2007.

The "Basis" column at the beginning of each page of each version of Table 2.1 indicates the origin of the important inputs: "NAT" indicates national trends, "VY" indicates Vermont Yankee historical trends and data, "VYCo" indicates projections by the Vermont Yankee Corporation, "DPS" are from the DPS Avoided Cost Report, "Hydro Q" are recent Hydro Quebec contracts, and "C&LM" are the assumed costs due to an energy efficiency program.

Table 2.1.A calculates the net benefit of Vermont Yankee by assuming the cost and capacity factor of Vermont Yankee will follow the trends set by domestic nuclear plants, while replacement costs will be equivalent to the avoided costs due to purchases from small power producers. Based on this case, Vermont ratepayers can expect to pay more for Vermont Yankee than it is worth, every year for the rest of its life, and pay an extra $958 million in present value terms by 2007, if Vermont Yankee continues to operate.

Table 2.1.B displays the result of assuming Vermont Yankee's performance and costs continue at the standards set by its 13 year life. Replacement power costs are still from DPS. Vermont Yankee is economical in a few years, after the year 2000, but it is still more expensive than replacement power overall, by $190 million. This is probably the most realistic comparison presented in this section, if one believes that Vermont Yankee's performance will continue to surpass national averages. Other nuclear power plants who once performed exceptionally by industry standards, such as Browns Ferry 1, 2 and 3, and Peach Bottom 2 and 3, have since encountered major problems.

Table 2.1.C repeats the analysis of Table 2.1.B, but uses Hydro Quebec contracts as a replacement cost. Since the HQ contract would provide more energy than the same amount of Vermont Yankee, the replacement power cost is overstated. The HQ contract cost estimate is probably overstated for other reasons, as well, as discussed in Section 4. Under these cost assumptions, Vermont Yankee is less expensive than HQ for 1989-1998, and more expensive thereafter. This comparison is somewhat deceptive, since the costs of capital additions in the 1990s are mostly recovered after the year 2000. The present value of Vermont Yankee net costs through 2007 is $60.4 million, indicating that Vermont Yankee is not economic even under this most optimistic set of assumptions.

Table 2.1.D combines the national performance projections of Table 2.1.A with the HQ replacement cost figures of Table 2.1.C. Vermont

Yankee is economical into the early 1990s, on a yearly basis, but is very uneconomical over its life. Again, the early years of the plant's operation can not be separated from later cost recovery for capital additions in the early years.

Table 2.1.E compares projections based on Vermont Yankee's historical performance with replacement power available at 3 cents/KWH due to a vigorous program of conservation and load management. Under these assumptions, Vermont Yankee is very clearly uneconomical over its operating life, costing Vermont ratepayers an additional $557.6 million in present value terms by 2207, if the plant continues to operate.

3. Analyses of Historical Data

This section explains how we derived the costs and other Vermont Yankee operating parameters.

Some of the cost input parameters were taken directly from Vermont Yankee Corporation sources, and are therefore not derived in this section. These include:

- Vermont Yankee capacity: We generally used the Design Electrical Rating (DER) of 514 MW. However, some data was stated in terms of Maximum Generator Nameplate (MGN) rating. In these cases we used Vermont Yankee's MGN rating of 563 MW.
- Vermont Yankee fuel costs: We adopted the projection in Appendix F of the DPS Report. Based on more detailed information for Pilgrim, we assumed that 25% of fuel costs are fixed carrying costs of the fuel inventory, and that the other 75% vary with energy output.

3.1. Capacity Factors

We defined the Vermont case as a continuation of Vermont Yankee's past performance. Since nuclear plants usually undergo a breaking-in process, we used only Vermont Yankee's mature performance history, which we defined as starting on January 1, 1978, when the unit had been in operation for five years. We calculated the capacity factor using both the NEPOOL Winter Rating and the DER. As seen in Table 3.1, Vermont Yankee has performed at an average capacity factor of 71.5% using the DER rating.

The National capacity factor projection was taken from our latest regressions on BWR capacity factors. These regressions, which include data through 1986 (data for 1987 has just recently become available), are shown in Table 3.2. These are the best-fit equations for capacity factor as a function of unit size, age, and other factors.

Table 3.3 shows the results of applying the characteristics of Vermont Yankee to Equations 3 and 4 from Table 3.2. The first line shows the expected capacity factor in years without a refueling outage, while the second line shows the results with a refueling. The third line computes an average capacity factor, assuming that Vermont Yankee refuels in two years out of three, which is the refueling pattern generally assumed for BWRs. The right-hand column computes the average of the two more optimistic cases, which omit the data from the worst accident at a US BWR, the cable fire at Brown's Ferry. The resulting industry-wide average is 57.4%, with 56.3% in years with refuelings and 66.8% in years without a refueling outage.

Applying the national refueling coefficient to Vermont Yankee's average experience produces a DER capacity factor of 78.9% without a refueling, and 68.4% with a refueling outage. See Table 3.1.

3.2. Non-Fuel Station O&M

We base all of our analyses of non-fuel O&M on data as reported for each nuclear plant by the operating utility to the FERC in its Annual Report (FERC Form 1).[4] This data shows a strong upward trend, even after adjustments for inflation. Hence, we estimate the trend in O&M expenses, rather than a simple historical average.

Table 3.4 displays the historical O&M experience of Vermont Yankee. The projections in Column 2 assume that real annual O&M expense increases linearly, at the least-squares growth rate determined by the regression on Vermont Yankee data, also shown in Table 3.4. Column 3 of Table 3.4 reduces the projection to 55%, which is the share of Vermont Yankee used by Vermont utilities. This projection is then inflated to nominal dollars in Column 4.

Table 3.5 presents the results of three regressions on O&M data for all light water reactors in the nation, a total of 534 observations. All costs are stated in 1983 dollars and deflated with the GNP deflator. The equations in this table indicate that real O&M costs for all plants have increased at about 12% annually,[5] and that

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4. Not all the expenses related to owning and operating the plant are included in this category. For example, pensions, employment taxes, and other employee benefits are not allocated to the plant, even though the direct labor expenses are treated by plant. In addition, legal, regulatory, public relations, and similar home-office functions are excluded from station O&M. We captured these other O&M expenses in the Overhead category.

5. The base of the natural log, e, raised to the coefficient of YEAR, .11, equals 1.12.

the economies-of-scale factor (the coefficient of ln(MW/unit) for nuclear O&M is about .5. Doubling the size of a plant (in Equation 1) or of a unit (in Equations 2 and 3) increases the O&M cost by about 43%.[6]

Equation 1 indicates that, once plant size has been accounted for, the number of units is inconsequential, and the effect on O&M expense is statistically insignificant. Equation 2 measures size as MW per unit, and finds that the effect of adding a second identical unit is about the same as the effect of doubling the size of the first unit. Equation 3 tests for extra costs in the Northeast, which are commonly found in studies of nuclear plant construction and operating costs, but is otherwise identical to Equation 2. Indeed, there is a highly significant differential: Northeast plants cost 23% more to operate than other plants (using the definition of North Atlantic from the Handy-Whitman index). We use this equation as the basis for our O&M projection.

Projections based on Equation 3 can be seen in Table 3.6. Column 1 increases at a real geometric growth rate, and column 4 grows at the increment between 1989 and 1990. Column 5 inflates the linear projections to nominal dollars, and column 6 is Vermont's

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6. In Equation 2, the base of the natural log, e, raised to .53*ln(MW/unit) equals (MW/unit)^.53. If we double the MW size of one unit, the result changes by a factor of 2^.52 = 1.43.

percentage of the total O&M expense.

Table 3.7 compares O&M expenses based on Vermont Yankee's historical experience with O&M expenses projected linearly from the regression on National data (Table 3.6, column 6). While the two projections are quite similar in 1989, they differ by over 100 million in 2007.

3.3. Capital Additions

We compiled net annual capital additions data for all nuclear power plants reporting total cost data on the FERC Form 1 and DOE compilations of FERC Form 1 data, through 1986.[7] Each plant is included for all years in which no units were added or deleted, and for which the data were not clearly in error. The available experience totaled 616 plant-years of operation. The net capital additions are defined as the difference in plant cost between subsequent years, and are deflated by the appropriate regional Handy-Whitman index for nuclear construction, which itself has increased at 1.35% above the GNP inflation rate from 1970-87.

7. The large steam plant cost data is reported in slightly different formats in various sources and for various years: both the plant cost data and O&M data are now reported on page 403 of the FERC Form 1.

Net capital additions vary with a number of factors, and vary greatly from year to year, complicating statistical analyses. A review of the data indicates that:

- large plants have lower capital additions per kilowatt-year than do small plants,
- multi-unit plants have lower capital additions per kilowatt-year than do single-unit plants,
- Northeastern plants have higher capital additions than those in other parts of the country, and
- capital additions per kilowatt-year have generally been rising over time, despite the greater prevalence of large and multi-unit plants in the later data.

Table 3.8 shows the net capital additions experience for Vermont Yankee from commercial operation date to 1986. The average annual net capital additions over the life of Vermont Yankee have been 22.87, measured in $/kw. The average for the 1980s is 31.94, and is used to project capital additions for the remaining life of Vermont Yankee in Column 1 of Table 3.11.[8] The Handy-Whitman inflation rate is assumed to be 1.35% more than the DPS-assumed GNP inflation rate.

Table 3.9 presents the annual average net capital additions per kilowatt for all plants for each year since 1972. Over the last eight years, the average for all plants was $27.9/kw-yr; over the last six years, the average has been $31.8/kW-yr.

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8. These averages are based on the MGN rating for Vermont Yankee, which is 563.

The average capital additions per kilowatt for all plants is likely to be less than that for Vermont Yankee for two reasons. First, Vermont Yankee is a single unit, and twin- or triple-unit plants usually experience lower costs per kilowatt than single units. Second, Vermont Yankee is a fairly small nuclear unit by current standards, and costs per kilowatt generally decline substantially with unit size. Therefore, Table 3.9, column 3 displays annual capital additions for single units between 300 and 800 MW, a size range comparable to Vermont Yankee. The average net capital additions per kilowatt for these plants since 1978 is $43.1, and for the last six years is $48.82.

Table 3.10 displays the results of performing a regression analysis on national capital additions data. The regression was used to project capital additions for a one unit, 563 MW plant for each year of Vermont Yankee's remaining life. The projection is then escalated using the Handy-Whitman index through 1987, and using DPS inflators plus the historical difference between the Handy-Whitman index and the implicit GNP deflator (1.35%) thereafter. Column 2 displays the inflated projection, reduced to the percentage of Vermont Yankee used by Vermont utilities.

Table 3.11 summarizes the two methods of projecting capital additions for Vermont Yankee. In the case based on averages of Vermont Yankee data, the average $/kW-yr is multiplied by 55% of the rated capacity of Vermont Yankee (310 MW, expressed as MGN rating), and divided by 1000 to produce the capital additions for 1983 in millions of dollars. The cost in 1983 dollars is escalated to 1988 dollars by the Handy-Whitman index from 1983-87, and at DPS inflators plus 1.35% thereafter. The capital additions projection based on Vermont Yankee data indicates a slightly lower rate of growth than that based on the national data.

Table 3.11 displays <u>net</u> capital additions, and therefore understates the true level of capital additions. The net capital additions are the difference between the gross additions (new equipment installed at the plant) and retirements (existing equipment removed from service). Someone must pay for both the new equipment and the undepreciated portion of the investment in the old equipment: ratepayers usually pay for these interim retirements through adjustments to depreciation rates.

Table 6-3 of the DPS report gives some idea of the size of the underestimation. The retirements are highly variable from year to year, ranging from 10% of capital additions in 1985 to 1% in 1982. It is clear that our use of net capital additions introduces some optimism, but our sample is too limited (and the effect is apparently too small) to justify any explicit correction.

3.4. Useful Plant Life

Vermont Yankee Corporation estimates that Vermont Yankee will remain in service until the year 2007, at which time it would be 35 years of age. We used this projection in all runs. This assumption seems to have been based on the term of the operating license for Vermont Yankee. There is still very little experience with the longevity of nuclear power plants. What little experience is available suggests that the useful lives of nuclear units may be much shorter than 35 years. The five small plants which entered commercial service in the early 1960s would be 20-26 years old today, if all had survived.[9] Of this cohort, Indian Point 1, Humboldt Bay, and Dresden 1 have been retired (formally or de facto), after only 12, 13, and 18 years of operation, respectively. Only Big Rock Point and Yankee Rowe remain from the original group. The oldest and largest of the survivors, Yankee Rowe, has been in service only since 1961, and is thus only 27.[10] Even with an excellent 77.5% capacity factor, Yankee Rowe's O&M (excluding overheads and capital additions) for 1986 was 3.71 cents/kWh, which is higher than DPS's avoided cost projections (in 1986 $, including capacity) through 1993. Including the other costs and even modest real growth in O&M, Yankee Rowe will probably be uneconomical in each of its remaining years in service, until its scheduled retirement in 1997.[11] Lacrosse, a 50 MW unit which entered service in November 1969, was retired for economic reasons in April 1987, after just 17.5 years of

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9. This group excludes the exotic demonstration reactors, some of which used liquid metal coolant, organic moderation, and other technologies very different than the light water reactors which have prevailed in US nuclear power plant design. We have also excluded some very small demonstration reactors which operated for only a few years.

10. It is also only a 175 MW unit.

11. Big Rock Point's O&M cost 3.35 cents/kWh in 1986, at a 74% capacity factor.

service.

The first units of more than 300 MW went commercial in January 1968: they have just reached age 20. The only clear retirement among this group is Three Mile Island 2, which operated for only a few months prior to its accident. Various nuclear units which are currently on protracted shutdowns due to safety and design problems may never reopen, but such units may be shut down for an extended period before it becomes clear that they have reached the end of their useful lives.

To summarize, Vermont Yankee Corporation is projecting that Vermont Yankee will survive about 75% longer than has the oldest domestic unit over 300 MW, and 25% longer than the oldest domestic commercial power reactor of any size.

Appendix 1 is a paper by Michael B. Meyer, updating the analysis of the operating life of nuclear power plants contained in our earlier report to the NRC (Chernick, et al., 1981, cited in Appendix 1). Depending on the data set utilized, the data indicate a median useful life for nuclear power plants of anywhere from 20 to 35 years. Unfortunately, the data, no matter how defined, are quite sparse.

The same forces which resulted in the early retirement of older units all still exist. High costs of O&M and necessary capital additions, mostly due to regulatory considerations, were responsible for the retirement of most of the small pre-1965 reactors during the 1970s.

O&M expenses have continued to grow much faster than inflation, and capital additions have been much higher in the 1980s than in the 1970s.

Vermont Yankee and other medium-sized nuclear units built in the early 1970s have been less sensitive to O&M and capital additions costs than have the smaller and older units. Economies of scale have made these units more economical to operate than the smaller units. However, as demonstrated in this report, continued growth in real O&M costs at historical rates, especially combined with the continuation of recent rates of capital additions, could render larger (over 300 MW), later (post-1968) nuclear plants prohibitively expensive to operate. Of the post-1968 nuclear units, Vermont Yankee is more vulnerable than average, due to its relatively small size, lack of any sister units to share costs, and design problems due to its early vintage and Mark I containment. On the whole, the use of the 35-year life and a retirement date of 2007 is probably quite optimistic.

3.5. Overheads

Not all of the costs associated with operating a nuclear power plant are listed by the utility as O&M costs for that plant. Some categories of costs are accounted for in other types of accounts, such as insurance, payroll taxes, and employee benefits. Table 3.12 displays the overhead expenses for Vermont Yankee between the years of 1981 and 1986. Line 8 of this table shows the overhead expenses for each year expressed as a percentage of the total non-fuel station O&M. The percentages vary from 16.6% in 1981, to 26% in 1985. The average overhead expense from 1980 through 1986 was 21.5%, while the average in the last three years was 24.1%. There is a general upward trend in the ratios of recent years, but it is difficult to determine whether this trend is likely to persist. In calculating the overhead expense for Vermont Yankee in Section 2 of this report, we used an overhead ratio of 22.8%, which is the average of the seven-year and three-year averages.

4. Replacement Power Costs

We analyze the cost of replacing Vermont Yankee's capacity and energy contribution in two steps. First, we examine the Vermont utilities' load and capacity situation for its current capacity plans, to determine when Vermont would require additional capacity to meet its load requirements. Table 4.1 presents the load and capacity projections for Vermont utilities through 2006, taken from the DPS filing. Column 7 in this table shows that a Vermont Yankee shutdown would produce a deficiency in capacity requirements of less than 100 MW through 1994, and exceeding 200 MW in 1997. In 2005, the deficiency exceeds the capacity contributed by Vermont Yankee.

Second, we estimate the cost of replacing Vermont Yankee power. Table 4.2 displays the avoided capacity and energy costs due to purchases from small power producers, as estimated by the DPS. The DPS capacity costs assumed a purchase from NU through 1993, and the construction of a gas turbine in 1994, and used a levelized cost of the new turbine. We have restated the gas turbine costs in a real-levelized manner (so that costs rise with inflation), in a manner comparable to that used by the Massachusetts DPU for determining avoided costs. This restatement is necessary because Vermont Yankee would only replace the new turbine for the first half of its life. If Vermont Yankee is retired early, the turbine will be built sooner, but at a lower cost, while if Vermont Yankee is retired later, the turbine will be constructed later and at higher cost. The real-levelized methodology recognizes this relationship, and credits Vermont Yankee in each year with the benefit of delaying the gas turbine for one year. Also, the real-levelized analysis reveals that the new gas turbine would be less expensive than the NU purchase for 1992 and 1993, so we have used the new-unit cost from 1992 onwards.

Table 4.4 displays the capacity and energy costs which were offered in recent sales by Hydro Quebec. The Hydro Quebec costs include transmission costs which would probably not be incurred by addition contracts or extensions, since equipment and rights of way already exist and would not have to be duplicated.

TABLES

TABLE 1.1: SUMMARY OF CASES AND RESULTS

Case	Source of VT Yankee Performance Projections	Source of Replacement Costs	Present Value Net Cost of VT Yankee ($ Million)	# of Years Yankee shows net savings 1989-2007
A	National Data	DPS Supply Plan	957.8	0
B	VT Yankee History	DPS Supply Plan	189.9	2
C	VT Yankee History	Hydro Quebec	60.7	9
D	National Data	Hydro Quebec	744.7	1
E	VT Yankee History	Conservation Program	557.6	0
DPS	VT Yankee Company	DPS Supply Plan [1]	-343	
		[2]	-569 - -612	

NOTES:
[1] Shutdown not initiated by the State of Vermont.
[2] Shutdown initiated by the State of Vermont.

NOTES TO TABLE 2.1.A - TABLE 2.1.E

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[1] Cappital Additons (Jan-Dec): from Table 3.11, see Table 2.3.

[2] Average Gross Plant (as of July): [2<t-1>]+.5*([1<t-1>]+[1<t>])

[3] Book Depreciation: ([5<t-1>]+.5*([1<t-1>]+[1<t>]))/2007-t+1.

[4] Accumulated Depreciation: [4<t-1>+[3<t>].

[5] Net Plant: [2<t>]-[4<t>].

[6] Tax Depreciation: 150% declining balance; 150%/15*([2<t>]-[7<t-1>].

[7] Accumulated Tax Depreciation: [7<t-1>]+[6<t>].

[8] Deferred Taxes: 34%*([7<t>]-[5<t>].

[9] Rate Base: [5<t>]-[8<t>].

[10] Return on Rate Base: [9<t>]*10.76%; see Table 2.2.

[11] Income Taxes: [9<t>]*3.76%; see Table 2.2.

[12] Property Taxes: 2%*[5<t>]

[13] Capital Additions Cost Recovery: [3<t>]+[10<t>]+[11<t>]+[12<t>].

[14] Vermont Use Tax: From appendix F-2, F-3, Technical Report no. 12, State of Vermont Dept. of Public Service.

[15] O&M Expenses: from Table 3.7, see Table 2.3.

[16] Overheads: [15<t>]*22.81%; see Table 3.12.

[17] Total Non-Fuel Costs: [13<t>]+[14<t>]+[15<t>]+[16<t>].

[18] Capacity Factor: refuel every third year; see Table 2.3.

[19] Fuel: Vermont Yankee Fuel (Appendix F-2, F-3) * (.25+.75*[18<t>]/VY CO. capacity factor.

[20] Total Vermont Yankee Cost: [17<t>]+[19<t>].

[21] Replacement Capacity Cost: from Table 4.2 or 4.4; see Table 2.3; (Cost*(55%*514*1000/1000000).

[22] Replacement Energy Cost: from Table 4.2 or 4.4; see Table 2.3; (Cost*8670*55%*514*[18<t>])/1000000.

[23] Net Vermont Yankee Cost: [20<t>]-[21<t>]-[22<t>].

[24] Vermont Yankee Cost/mwh: [20<t>]/(8760*55%*514*[18<t>]).

[26] Present Value of Net cost: Running total calculated at 10.5%; see VT DPS Technical Report no. 12.

TABLE 2.1.A: VERMONT YANKEE COST PROJECTIONS VS. REPLACEMENT COSTS ($ MILLION)

($ Million)	BASIS	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Post-1988 Additions													
1. Capital Additions	NAT	17.2	18.3	19.6	21.0	22.5	24.1	25.8	27.7	29.6	31.8	34.0	36.4
2. Average Gross Plant		8.6	26.3	45.3	65.6	87.4	110.7	135.7	162.5	191.1	221.8	254.7	289.9
3. Book Depreciation		0.5	1.4	2.6	3.8	5.3	6.9	8.9	11.1	13.7	16.8	20.4	24.8
4. Accumulated Book Depreciation		0.5	1.9	4.4	8.3	13.5	20.5	29.3	40.4	54.1	70.9	91.3	116.2
5. Net-Plant (as of July)		8.1	24.4	40.9	57.4	73.9	90.2	106.3	122.0	137.0	150.9	163.4	173.8
6. Tax Depreciation		0.9	2.5	4.2	5.8	7.4	9.0	10.6	12.2	13.9	15.5	17.3	19.1
7. Accumulated Tax Depreciation		0.9	3.4	7.6	13.4	20.8	29.8	40.4	52.6	66.4	82.0	99.3	118.3
8. Deferred Taxes		0.1	0.5	1.1	1.7	2.5	3.2	3.8	4.1	4.2	3.8	2.7	0.7
9. Rate Base		8.0	23.9	39.8	55.6	71.4	87.1	102.6	117.9	132.8	147.1	160.7	173.0
10. Return on Rate Base		0.9	2.6	4.3	6.0	7.7	9.4	11.0	12.7	14.3	15.8	17.3	18.6
11. Income Taxes		0.3	0.9	1.5	2.1	2.7	3.3	3.9	4.4	5.0	5.5	6.0	6.5
12. Property Taxes		0.2	0.5	0.8	1.1	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.5
13. Capital Additions Cost Recovery		1.8	5.4	9.1	13.0	17.1	21.4	25.9	30.6	35.7	41.2	47.0	53.4
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15. O&M Expenses	NAT	50.2	59.3	69.1	79.9	91.8	104.7	118.8	134.2	151.0	169.3	189.1	210.7
16. Overheads		11.5	13.5	15.8	18.2	20.9	23.9	27.1	30.6	34.4	38.6	43.1	48.1
17. Total Non-fuel cost		63.7	78.4	94.2	111.4	130.0	150.2	172.0	195.7	221.4	249.2	279.5	312.4
18. Capacity Factor	NAT	56%	56%	67%	56%	56%	67%	56%	56%	67%	56%	56%	67%
19. Fuel		18.8	20.7	23.5	20.8	21.3	26.5	23.9	24.5	31.6	27.3	28.0	33.8
20. Total Vermont Yankee Cost		82.4	99.1	117.7	132.3	151.3	176.6	195.9	220.1	252.9	276.6	307.5	346.3
21. Replacement Capacity Cost	DPS	7.4	8.2	10.4	11.9	12.6	13.4	14.1	15.0	15.8	16.7	17.7	18.7
22. Replacement Energy Cost	DPS	38.6	39.3	60.2	53.8	54.8	78.0	74.4	82.7	118.0	110.7	124.7	177.2
23. Net Vermont Yankee Cost		36.5	51.5	47.1	66.5	83.9	85.3	107.4	122.4	119.1	149.1	165.1	150.3
24. Vermont Yankee Cost $/MWH		59.2	71.1	71.2	94.7	108.6	106.8	140.6	157.6	152.9	198.5	220.7	208.8
25. Replacement Cost $/MWH		33.0	34.1	42.7	47.1	48.4	55.2	63.5	69.9	80.9	91.5	102.2	118.1
26. Cummulative Present Value of Net Cost		33.0	75.2	110.1	154.7	205.7	252.5	305.9	361.0	409.5	464.4	519.5	564.8

($ Million)	BASIS	2001	2002	2003	2004	2005	2006	2007	NPV 10.5%
Post-1988 Additions									
1. Capital Additions	NAT	39.0	41.8	44.8	48.0	51.4	55.1	59.0	
2. Average Gross Plant		327.7	368.1	411.4	457.8	507.5	560.7	617.7	
3. Book Depreciation		30.2	37.0	45.6	57.2	73.8	100.4	157.4	141.4
4. Accumulated Book Depreciation		146.4	183.3	228.9	286.2	359.9	460.3	617.7	
5. Net-Plant (as of July)		181.3	184.8	182.5	171.6	147.5	100.4	0.0	
6. Tax Depreciation		20.9	22.9	24.9	27.1	29.3	31.7	34.3	
7. Accumulated Tax Depreciation		139.3	162.1	187.1	214.1	243.5	275.2	309.4	
8. Deferred Taxes		-2.4	-7.2	-14.2	-24.5	-39.6	-62.9	-104.8	
9. Rate Base		183.7	192.0	196.7	196.1	187.1	163.3	104.8	
10. Return on Rate Base		19.8	20.7	21.2	21.1	20.1	17.6	11.3	81.9
11. Income Taxes		6.9	7.2	7.4	7.4	7.0	6.1	3.9	28.6
12. Property Taxes		3.6	3.7	3.6	3.4	3.0	2.0	0.0	14.6
13. Capital Additions Cost Recovery		60.5	68.5	77.8	89.1	103.9	126.1	172.6	266.6
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.6
15. O&M Expenses	NAT	234.2	259.7	287.3	317.3	349.7	384.9	422.9	1129.9
16. Overheads		53.4	59.2	65.5	72.4	79.8	87.8	96.5	257.7
17. Total Non-fuel cost		348.3	387.6	430.9	479.0	533.6	599.0	692.2	1655.8
18. Capacity Factor	NAT	56%	56%	67%	56%	56%	67%	56%	
19. Fuel		29.3	29.9	36.1	31.5	32.2	38.9	34.3	205.5
20. Total Vermont Yankee Cost		377.6	417.6	467.0	510.4	565.8	637.9	726.5	1861.3
21. Replacement Capacity Cost	DPS	19.8	20.9	22.1	23.4	24.8	26.2	27.7	115.3
22. Replacement Energy Cost	DPS	167.8	167.7	232.8	209.8	215.2	282.6	253.9	788.2
23. Net Vermont Yankee Cost		190.0	228.9	212.1	277.2	325.8	329.0	444.9	
24. Vermont Yankee Cost $/MWH		271.0	299.7	282.4	365.3	406.1	385.7	521.4	
25. Replacement Cost $/MWH		134.7	135.4	154.1	167.0	172.2	186.7	202.1	
26. Cummulative Present Value of Net Cost		616.7	673.3	720.7	776.8	836.5	891.0	957.8	

($ Million)	BASIS	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Post-1988 Additions													
1. Capital Additions	VTY	12.1	12.7	13.5	14.4	15.2	16.2	17.2	18.2	19.3	20.5	21.8	23.1
2. Average Gross Plant		6.0	18.4	31.6	45.5	60.3	76.0	92.7	110.4	129.1	149.1	170.2	192.6
3. Book Depreciation		0.3	1.0	1.8	2.7	3.6	4.8	6.0	7.5	9.2	11.2	13.6	16.4
4. Accumulated Book Depreciation		0.3	1.3	3.1	5.8	9.4	14.2	20.2	27.7	36.9	48.1	61.7	78.1
5. Net-Plant (as of July)		5.7	17.1	28.5	39.8	50.9	61.9	72.5	82.7	92.2	100.9	108.5	114.5
6. Tax Depreciation		0.6	1.8	2.9	4.0	5.1	6.2	7.2	8.3	9.3	10.4	11.4	12.5
7. Accumulated Tax Depreciation		0.6	2.4	5.3	9.3	14.4	20.5	27.8	36.1	45.4	55.7	67.2	79.7
8. Deferred Taxes		0.1	0.4	0.7	1.2	1.7	2.2	2.6	2.8	2.9	2.6	1.9	0.6
9. Rate Base		5.6	16.8	27.7	38.6	49.2	59.7	69.9	79.8	89.3	98.3	106.6	114.0
10. Return on Rate Base		0.6	1.8	3.0	4.1	5.3	6.4	7.5	8.6	9.6	10.6	11.5	12.3
11. Income Taxes		0.2	0.6	1.0	1.4	1.9	2.2	2.6	3.0	3.4	3.7	4.0	4.3
12. Property Taxes		0.1	0.3	0.6	0.8	1.0	1.2	1.4	1.7	1.8	2.0	2.2	2.3
13. Capital Additions Cost Recovery		1.2	3.8	6.4	9.0	11.8	14.7	17.6	20.8	24.0	27.5	31.2	35.2
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15. O&M Expenses	VTY	40.1	44.7	49.8	55.3	61.4	67.9	75.0	82.8	91.1	100.1	109.9	120.5
16. Overheads		9.2	10.2	11.4	12.6	14.0	15.5	17.1	18.9	20.8	22.8	25.1	27.5
17. Total Non-fuel cost		50.7	58.8	67.7	77.2	87.4	98.3	110.0	122.6	136.1	150.7	166.4	183.3
18. Capacity Factor	VTY	68%	68%	79%	68%	68%	79%	68%	68%	79%	68%	68%	79%
19. Fuel		21.5	23.8	26.4	23.9	24.4	29.8	27.5	28.1	35.5	31.4	32.1	38.1
20. Total Vermont Yankee Cost		72.3	82.6	94.1	101.1	111.8	128.1	137.5	150.6	171.6	182.0	198.5	221.4
21. Replacement Capacity Cost	DPS	7.4	8.2	10.4	11.9	12.6	13.4	14.1	15.0	15.8	16.7	17.7	18.7
22. Replacement Energy Cost	DPS	46.9	47.8	71.1	65.4	66.5	92.1	90.4	100.5	139.4	134.5	151.5	209.3
23. Net Vermont Yankee Cost		18.0	26.6	12.6	23.8	32.6	22.6	33.0	35.2	16.4	30.8	29.3	-6.6
24. Vermont Yankee Cost $/MWH		42.7	48.8	48.2	59.6	66.1	65.6	81.2	88.8	87.8	107.6	117.2	113.0
25. Replacement Cost $/MWH		32.1	33.1	41.7	45.5	46.8	54.0	61.7	68.0	79.4	89.4	100.0	116.4
26. Cummulative Present Value of Net Cost		16.3	38.0	47.4	63.4	83.2	95.6	112.0	127.8	134.5	145.8	155.6	153.6

($ Million)	BASIS	2001	2002	2003	2004	2005	2006	2007	NPV 10.5%
Post-1988 Additions									
1. Capital Additions	VTY	24.5	26.0	27.6	29.3	31.1	33.0	35.0	
2. Average Gross Plant		216.4	241.7	268.5	296.9	327.1	359.1	393.1	
3. Book Depreciation		19.8	24.0	29.3	36.4	46.5	62.5	96.5	91.4
4. Accumulated Book Depreciation		97.8	121.8	151.1	187.6	234.1	296.6	393.1	
5. Net-Plant (as of July)		118.6	119.9	117.3	109.3	93.0	62.5	0.0	
6. Tax Depreciation		13.7	14.8	16.0	17.3	18.6	19.9	21.3	
7. Accumulated Tax Depreciation		93.4	108.2	124.2	141.5	160.1	180.0	201.3	
8. Deferred Taxes		-1.5	-4.6	-9.1	-15.7	-25.2	-39.7	-65.2	
9. Rate Base		120.1	124.5	126.5	125.0	118.2	102.2	65.2	
10. Return on Rate Base		12.9	13.4	13.6	13.4	12.7	11.0	7.0	54.5
11. Income Taxes		4.5	4.7	4.8	4.7	4.4	3.8	2.5	19.0
12. Property Taxes		2.4	2.4	2.3	2.2	1.9	1.3	0.0	9.8
13. Capital Additions Cost Recovery		39.6	44.4	50.0	56.8	65.5	78.6	106.0	174.7
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.6
15. O&M Expenses	VTY	131.9	144.2	157.5	171.9	187.4	204.1	222.1	686.1
16. Overheads		30.1	32.9	35.9	39.2	42.7	46.6	50.7	156.5
17. Total Non-fuel cost		201.7	221.7	243.7	268.1	295.9	329.5	379.0	1018.9
18. Capacity Factor	VTY	68%	68%	79%	68%	68%	79%	68%	
19. Fuel		33.6	34.3	40.6	36.1	36.9	43.7	39.3	234.2
20. Total Vermont Yankee Cost		235.3	256.1	284.3	304.2	332.7	373.2	418.3	1253.1
21. Replacement Capacity Cost	DPS	19.8	20.9	22.1	23.4	24.8	26.2	27.7	115.3
22. Replacement Energy Cost	DPS	203.9	203.8	274.9	254.9	261.4	333.8	308.4	947.8
23. Net Vermont Yankee Cost		11.6	31.4	-12.7	25.8	46.5	13.2	82.2	
24. Vermont Yankee Cost $/MWH		139.0	151.3	145.6	179.2	196.6	191.1	247.1	
25. Replacement Cost $/MWH		132.2	132.8	152.1	164.0	169.1	184.3	198.6	
26. Cummulative Present Value of Net Cost		156.8	164.5	161.7	166.9	175.4	177.6	189.9	

($ Million)	BASIS	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Post-1988 Additions													
1. Capital Additions	VTY	12.1	12.7	13.5	14.4	15.2	16.2	17.2	18.2	19.3	20.5	21.8	23.1
2. Average Gross Plant		6.0	18.4	31.6	45.5	60.3	76.0	92.7	110.4	129.1	149.1	170.2	192.6
3. Book Depreciation		0.3	1.0	1.8	2.7	3.6	4.8	6.0	7.5	9.2	11.2	13.6	16.4
4. Accumulated Book Depreciation		0.3	1.3	3.1	5.8	9.4	14.2	20.2	27.7	36.9	48.1	61.7	78.1
5. Net-Plant (as of July)		5.7	17.1	28.5	39.8	50.9	61.9	72.5	82.7	92.2	100.9	108.5	114.5
6. Tax Depreciation		0.6	1.8	2.9	4.0	5.1	6.2	7.2	8.3	9.3	10.4	11.4	12.5
7. Accumulated Tax Depreciation		0.6	2.4	5.3	9.3	14.4	20.6	27.8	36.1	45.4	55.7	67.2	79.7
8. Deferred Taxes		0.1	0.4	0.7	1.2	1.7	2.2	2.6	2.8	2.9	2.6	1.9	0.6
9. Rate Base		5.6	16.8	27.7	38.6	49.2	59.7	69.9	79.8	89.3	98.3	106.6	114.0
10. Return on Rate Base		0.6	1.8	3.0	4.1	5.3	6.4	7.5	8.6	9.6	10.6	11.5	12.3
11. Income Taxes		0.2	0.6	1.0	1.4	1.9	2.2	2.6	3.0	3.4	3.7	4.0	4.3
12. Property Taxes		0.1	0.3	0.6	0.8	1.0	1.2	1.4	1.7	1.8	2.0	2.2	2.3
13. Capital Additions Cost Recovery		1.2	3.8	6.4	9.0	11.8	14.7	17.6	20.8	24.0	27.5	31.2	35.2
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15. O&M Expenses	VTY	40.1	44.7	49.8	55.3	61.4	67.9	75.0	82.8	91.1	100.1	109.9	120.5
16. Overheads		9.2	10.2	11.4	12.6	14.0	15.5	17.1	18.9	20.8	22.8	25.1	27.5
17. Total Non-fuel cost		50.7	58.8	67.7	77.2	87.4	98.3	110.0	122.6	136.1	150.7	166.4	183.3
18. Capacity Factor	VTY	68%	68%	79%	68%	68%	79%	68%	68%	79%	68%	68%	79%
19. Fuel		21.5	23.8	26.4	23.9	24.4	29.8	27.5	28.1	35.5	31.4	32.1	38.1
20. Total Vermont Yankee Cost		72.3	82.6	94.1	101.1	111.8	128.1	137.5	150.6	171.6	182.0	198.5	221.4
21. Replacement Capacity Cost	HYDROQ	71.1	42.1	54.9	88.6	99.4	99.4	99.4	114.7	114.6	114.6	114.6	114.6
22. Replacement Energy Cost	HYDROQ	36.1	43.4	50.0	44.3	45.7	56.5	52.4	53.4	64.3	58.3	61.0	73.9
23. Net Vermont Yankee Cost		-35.0	-2.9	-10.9	-31.9	-33.3	-27.8	-14.3	-17.5	-7.3	9.1	22.9	32.8
24. Vermont Yankee Cost $/MWH		42.7	48.8	48.2	59.6	66.1	65.6	81.2	88.8	87.8	107.6	117.2	113.0
25. Replacement Cost $/MWH		63.3	50.5	53.7	78.3	85.7	79.8	89.7	99.1	91.6	102.2	103.8	96.3
26. Cummulative Present Value of Net Cost		-31.6	-34.0	-42.1	-63.4	-83.6	-98.9	-106.0	-113.9	-116.9	-113.5	-105.9	-96.0

($ Million)	BASIS	2001	2002	2003	2004	2005	2006	2007	NPV 10.5%
Post-1988 Additions									
1. Capital Additions	VTY	24.5	26.0	27.6	29.3	31.1	33.0	35.0	
2. Average Gross Plant		216.4	241.7	266.5	296.9	327.1	359.1	393.1	
3. Book Depreciation		19.8	24.0	29.3	36.4	46.5	62.5	96.5	91.4
4. Accumulated Book Depreciation		97.8	121.8	151.1	187.6	234.1	296.6	393.1	
5. Net-Plant (as of July)		118.6	119.9	117.3	109.3	93.0	62.5	0.0	
6. Tax Depreciation		13.7	14.8	16.0	17.3	18.6	19.9	21.3	
7. Accumulated Tax Depreciation		93.4	108.2	124.2	141.5	160.1	180.0	201.3	
8. Deferred Taxes		-1.5	-4.6	-9.1	-15.7	-25.2	-39.7	-65.2	
9. Rate Base		120.1	124.5	126.5	125.0	118.2	102.2	65.2	
10. Return on Rate Base		12.9	13.4	13.6	13.4	12.7	11.0	7.0	54.5
11. Income Taxes		4.5	4.7	4.8	4.7	4.4	3.8	2.5	19.0
12. Property Taxes		2.4	2.4	2.3	2.2	1.9	1.3	0.0	9.8
13. Capital Additions Cost Recovery		39.6	44.4	50.0	56.8	65.5	78.6	106.0	174.7
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.6
15. O&M Expenses	VTY	131.9	144.2	157.5	171.9	187.4	204.1	222.1	686.1
16. Overheads		30.1	32.9	35.9	39.2	42.7	46.6	50.7	156.5
17. Total Non-fuel cost		201.7	221.7	243.7	268.1	295.9	329.5	379.0	1018.9
18. Capacity Factor	VTY	68%	68%	79%	68%	68%	79%	68%	
19. Fuel		33.6	34.3	40.6	36.1	36.9	43.7	39.3	234.2
20. Total Vermont Yankee Cost		235.3	256.1	284.3	304.2	332.7	373.2	418.3	1253.1
21. Replacement Capacity Cost	HYDROQ	114.3	114.5	114.2	114.5	114.5	118.9	119.4	743.5
22. Replacement Energy Cost	HYDROQ	66.9	70.1	84.9	77.4	81.0	98.1	89.3	448.9
23. Net Vermont Yankee Cost		54.1	71.4	85.2	112.3	137.3	156.2	209.7	
24. Vermont Yankee Cost $/MWH		139.0	151.3	145.6	179.2	196.6	191.1	247.1	
25. Replacement Cost $/MWH		107.0	109.1	101.9	113.0	115.5	111.1	123.3	
26. Cummulative Present Value of Net Cost		-81.2	-63.6	-44.5	-21.8	3.3	29.2	60.7	

TABLE 2.1.D: VERMONT YANKEE COST PROJECTIONS VS. REPLACEMENT COSTS ($ MILLION)

($ Million)	BASIS	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Post-1988 Additions													
1. Capital Additions	NAT	17.2	18.3	19.6	21.0	22.5	24.1	25.8	27.7	29.6	31.8	34.0	36.4
2. Average Gross Plant		8.6	26.3	45.3	65.6	87.4	110.7	135.7	162.5	191.1	221.8	254.7	289.9
3. Book Depreciation		0.5	1.4	2.6	3.8	5.3	6.9	8.9	11.1	13.7	16.8	20.4	24.8
4. Accumulated Book Depreciation		0.5	1.9	4.4	8.3	13.5	20.5	29.3	40.4	54.1	70.9	91.3	116.2
5. Net-Plant (as of July)		8.1	24.4	40.9	57.4	73.9	90.2	106.3	122.0	137.0	150.9	163.4	173.8
6. Tax Depreciation		0.9	2.5	4.2	5.8	7.4	9.0	10.6	12.2	13.9	15.5	17.3	19.1
7. Accumulated Tax Depreciation		0.9	3.4	7.6	13.4	20.8	29.8	40.4	52.6	66.4	82.0	99.3	118.3
8. Deferred Taxes		0.1	0.5	1.1	1.7	2.5	3.2	3.8	4.1	4.2	3.8	2.7	0.7
9. Rate Base		8.0	23.9	39.8	55.6	71.4	87.1	102.6	117.9	132.8	147.1	160.7	173.0
10. Return on Rate Base		0.9	2.6	4.3	6.0	7.7	9.4	11.0	12.7	14.3	15.8	17.3	18.6
11. Income Taxes		0.3	0.9	1.5	2.1	2.7	3.3	3.9	4.4	5.0	5.5	6.0	6.5
12. Property Taxes		0.2	0.5	0.8	1.1	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.5
13. Capital Additions Cost Recovery		1.8	5.4	9.1	13.0	17.1	21.4	25.9	30.6	35.7	41.2	47.0	53.4
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15. O&M Expenses	NAT	50.2	59.3	69.1	79.9	91.8	104.7	118.8	134.2	151.0	169.3	189.1	210.7
16. Overheads		11.5	13.5	15.8	18.2	20.9	23.9	27.1	30.6	34.4	38.6	43.1	48.1
17. Total Non-fuel cost		63.7	78.4	94.2	111.4	130.0	150.2	172.0	195.7	221.4	249.2	279.5	312.4
18. Capacity Factor	NAT	56%	56%	67%	56%	56%	67%	56%	56%	67%	56%	56%	67%
19. Fuel		18.8	20.7	23.5	20.8	21.3	26.5	23.9	24.5	31.6	27.3	28.0	33.8
20. Total Vermont Yankee Cost		82.4	99.1	117.7	132.3	151.3	176.6	195.9	220.1	252.9	276.6	307.5	346.3
21. Replacement Capacity Cost	HYDROQ	71.1	42.1	54.9	88.6	99.4	99.4	99.4	114.7	114.6	114.6	114.6	114.6
22. Replacement Energy Cost	HYDROQ	29.7	35.7	42.4	36.5	37.6	47.9	43.2	44.0	54.4	48.0	50.2	62.6
23. Net Vermont Yankee Cost		-18.4	21.3	20.4	7.1	14.3	29.4	53.4	61.4	83.9	114.0	142.6	169.0
24. Vermont Yankee Cost $/MWH		59.2	71.1	71.2	94.7	108.6	106.8	140.6	157.6	152.9	198.5	220.7	208.8
25. Replacement Cost $/MWH		72.4	55.9	58.8	89.6	98.3	89.0	102.3	113.6	102.2	116.7	118.3	106.9
26. Cummulative Present Value of Net Cost		-16.6	0.8	15.9	20.7	29.4	45.5	72.1	99.7	133.8	175.8	223.4	274.4

($ Million)	BASIS	2001	2002	2003	2004	2005	2006	2007	NPV 10.5%
Post-1988 Additions									
1. Capital Additions	NAT	39.0	41.8	44.8	48.0	51.4	55.1	59.0	
2. Average Gross Plant		327.7	368.1	411.4	457.8	507.5	560.7	617.7	
3. Book Depreciation		30.2	37.0	45.6	57.2	73.8	100.4	157.4	141.4
4. Accumulated Book Depreciation		146.4	183.3	228.9	286.2	359.9	460.3	617.7	
5. Net-Plant (as of July)		181.3	184.8	182.5	171.6	147.5	100.4	0.0	
6. Tax Depreciation		20.9	22.9	24.9	27.1	29.3	31.7	34.3	
7. Accumulated Tax Depreciation		139.3	162.1	187.1	214.1	243.5	275.2	309.4	
8. Deferred Taxes		-2.4	-7.2	-14.2	-24.5	-39.6	-62.9	-104.8	
9. Rate Base		183.7	192.0	196.7	196.1	187.1	163.3	104.8	
10. Return on Rate Base		19.8	20.7	21.2	21.1	20.1	17.6	11.3	81.9
11. Income Taxes		6.9	7.2	7.4	7.4	7.0	6.1	3.9	28.6
12. Property Taxes		3.6	3.7	3.6	3.4	3.0	2.0	0.0	14.6
13. Capital Additions Cost Recovery		60.5	68.5	77.8	89.1	103.9	126.1	172.6	266.6
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.6
15. O&M Expenses	NAT	234.2	259.7	287.3	317.3	349.7	384.9	422.9	1129.9
16. Overheads		53.4	59.2	65.5	72.4	79.8	87.8	96.5	257.7
17. Total Non-fuel cost		348.3	387.6	430.9	479.0	533.6	599.0	692.2	1655.8
18. Capacity Factor	NAT	56%	56%	67%	56%	56%	67%	56%	
19. Fuel		29.3	29.9	36.1	31.5	32.2	38.9	34.3	205.5
20. Total Vermont Yankee Cost		377.6	417.6	467.0	510.4	565.8	637.9	726.5	1861.3
21. Replacement Capacity Cost	HYDROQ	114.3	114.5	114.2	114.5	114.5	118.9	119.4	743.5
22. Replacement Energy Cost	HYDROQ	55.1	57.7	71.9	63.7	66.7	83.1	73.5	373.1
23. Net Vermont Yankee Cost		208.3	245.3	280.9	332.3	384.6	435.9	533.6	
24. Vermont Yankee Cost $/MWH		271.0	299.7	282.4	365.3	406.1	385.7	521.4	
25. Replacement Cost $/MWH		121.5	123.6	112.5	127.5	130.0	122.1	138.4	
26. Cummulative Present Value of Net Cost		331.3	391.9	454.7	522.0	592.4	664.7	744.7	

($ Million)	BASIS	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Post-1988 Additions													
1. Capital Additions	VTY	12.1	12.7	13.5	14.4	15.2	16.2	17.2	18.2	19.3	20.5	21.8	23.1
2. Average Gross Plant		6.0	18.4	31.6	45.5	60.3	76.0	92.7	110.4	129.1	149.1	170.2	192.6
3. Book Depreciation		0.3	1.0	1.8	2.7	3.6	4.8	6.0	7.5	9.2	11.2	13.6	16.4
4. Accumulated Book Depreciation		0.3	1.3	3.1	5.8	9.4	14.2	20.2	27.7	36.9	48.1	61.7	78.1
5. Net-Plant (as of July)		5.7	17.1	28.5	39.8	50.9	61.9	72.5	82.7	92.2	100.9	108.5	114.5
6. Tax Depreciation		0.6	1.8	2.9	4.0	5.1	6.2	7.2	8.3	9.3	10.4	11.4	12.5
7. Accumulated Tax Depreciation		0.6	2.4	5.3	9.3	14.4	20.6	27.8	36.1	45.4	55.7	67.2	79.7
8. Deferred Taxes		0.1	0.4	0.7	1.2	1.7	2.2	2.6	2.8	2.9	2.6	1.9	0.6
9. Rate Base		5.6	16.8	27.7	38.6	49.2	59.7	69.9	79.8	89.3	98.3	106.6	114.0
10. Return on Rate Base		0.6	1.8	3.0	4.1	5.3	6.4	7.5	8.6	9.6	10.6	11.5	12.3
11. Income Taxes		0.2	0.6	1.0	1.4	1.9	2.2	2.6	3.0	3.4	3.7	4.0	4.3
12. Property Taxes		0.1	0.3	0.6	0.8	1.0	1.2	1.4	1.7	1.8	2.0	2.2	2.3
13. Capital Additions Cost Recovery		1.2	3.8	6.4	9.0	11.8	14.7	17.6	20.8	24.0	27.5	31.2	35.2
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15. O&M Expenses	VTY	40.1	44.7	49.8	55.3	61.4	67.9	75.0	82.8	91.1	100.1	109.9	120.5
16. Overheads		9.2	10.2	11.4	12.6	14.0	15.5	17.1	18.9	20.8	22.8	25.1	27.5
17. Total Non-fuel cost		50.7	58.8	67.7	77.2	87.4	98.3	110.0	122.6	136.1	150.7	166.4	183.3
18. Capacity Factor	VTY	68%	68%	79%	68%	68%	79%	68%	68%	79%	68%	68%	79%
19. Fuel		21.5	23.8	26.4	23.9	24.4	29.8	27.5	28.1	35.5	31.4	32.1	38.1
20. Total Vermont Yankee Cost		72.3	82.6	94.1	101.1	111.8	128.1	137.5	150.6	171.6	182.0	198.5	221.4
21. Replacement Capacity Cost	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22. Replacement Energy Cost	C&LM	55.9	58.8	71.8	66.0	69.6	84.9	77.8	82.6	100.5	92.1	97.4	119.2
23. Net Vermont Yankee Cost		16.4	23.8	22.3	35.2	42.2	43.1	59.6	68.1	71.1	89.9	101.0	102.1
24. Vermont Yankee Cost $/MWH		42.7	48.8	48.2	59.6	66.1	65.6	81.2	88.8	87.8	107.6	117.2	113.0
25. Replacement Cost $/MWH		33.0	34.7	36.7	38.9	41.1	43.5	46.0	48.6	51.4	54.4	57.6	60.9
26. Cummulative Present Value of Net Cost		14.8	34.3	50.9	74.5	100.1	123.8	153.4	184.1	213.0	246.2	279.9	310.7

($ Million)	BASIS	2001	2002	2003	2004	2005	2006	2007	NPV 10.5%
Post-1988 Additions									
1. Capital Additions	VTY	24.5	26.0	27.6	29.3	31.1	33.0	35.0	
2. Average Gross Plant		216.4	241.7	268.5	296.9	327.1	359.1	393.1	
3. Book Depreciation		19.8	24.0	29.3	36.4	46.5	62.5	96.5	91.4
4. Accumulated Book Depreciation		97.8	121.8	151.1	187.6	234.1	296.6	393.1	
5. Net-Plant (as of July)		118.6	119.9	117.3	109.3	93.0	62.5	0.0	
6. Tax Depreciation		13.7	14.8	16.0	17.3	18.6	19.9	21.3	
7. Accumulated Tax Depreciation		93.4	108.2	124.2	141.5	160.1	180.0	201.3	
8. Deferred Taxes		-1.5	-4.6	-9.1	-15.7	-25.2	-39.7	-65.2	
9. Rate Base		120.1	124.5	126.5	125.0	118.2	102.2	65.2	
10. Return on Rate Base		12.9	13.4	13.6	13.4	12.7	11.0	7.0	54.5
11. Income Taxes		4.5	4.7	4.8	4.7	4.4	3.8	2.5	19.0
12. Property Taxes		2.4	2.4	2.3	2.2	1.9	1.3	0.0	9.8
13. Capital Additions Cost Recovery		39.6	44.4	50.0	56.8	65.5	78.6	106.0	174.7
14. Vermont Use Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.6
15. O&M Expenses	VTY	131.9	144.2	157.5	171.9	187.4	204.1	222.1	686.1
16. Overheads		30.1	32.9	35.9	39.2	42.7	46.6	50.7	156.5
17. Total Non-fuel cost		201.7	221.7	243.7	268.1	295.9	329.5	379.0	1018.9
18. Capacity Factor	VTY	68%	68%	79%	68%	68%	79%	68%	
19. Fuel		33.6	34.3	40.6	36.1	36.9	43.7	39.3	234.2
20. Total Vermont Yankee Cost		235.3	256.1	284.3	304.2	332.7	373.2	418.3	1253.1
21. Replacement Capacity Cost	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22. Replacement Energy Cost	C&LM	109.0	115.3	140.7	129.3	136.4	166.5	152.6	695.6
23. Net Vermont Yankee Cost		126.3	140.8	143.6	174.8	196.3	206.7	265.7	-
24. Vermont Yankee Cost $/MWH		139.0	151.3	145.6	179.2	196.6	191.1	247.1	
25. Replacement Cost $/MWH		64.4	68.1	72.0	76.2	80.6	85.2	90.2	
26. Cummulative Present Value of Net Cost		345.2	380.0	412.1	447.5	483.4	517.7	557.6	

ABLE 2.2: RETURN AND TAXES

	% of capital [1]	return [2]	weighted average [3]	Income Taxes [4]
Long-term debt	46.42%	9.23%	4.28%	-
Preferred stock	8.82%	7.48%	0.65%	0.38%
Common stock	44.76%	13.00%	5.82%	3.38%
Total	100.00%	-	10.76%	3.76%

[1] From 1985 FERC Form 1, p. 218, excluding short-term debt.
[2] Ibid, except common return is updated.
[3] [1] * [2]
[4] [3]*((1/(1-36.71%))-1); Tax Rate = 1-(1-.34)*(1-.041).

Input	BASIS	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Capital Additions [1]	VTY	12.1	12.7	13.5	14.4	15.2	16.2	17.2	18.2	19.3	20.5	21.8	23.1
	NAT	17.2	18.3	19.6	21.0	22.5	24.1	25.8	27.7	29.6	31.8	34.0	36.4
O&M [2]	VTY	40.1	44.7	49.8	55.3	61.4	67.9	75.0	82.8	91.1	100.1	109.9	120.5
	NAT	50.2	59.3	69.1	79.9	91.8	104.7	118.8	134.2	151.0	169.3	189.1	210.7
Capacity Factor [3]	VTY	68%	68%	79%	68%	68%	79%	68%	68%	79%	68%	68%	79%
	NAT	56%	56%	67%	56%	56%	67%	56%	56%	67%	56%	56%	67%
	VY CO.	77%	77%	91%	77%	77%	91%	77%	77%	91%	77%	77%	91%
Replacement Capacity [4]	DPS	26.1	29.0	36.8	42.3	44.7	47.3	50.0	52.9	55.9	59.2	62.6	66.2
	HYDRO	251.6	149.0	194.3	313.6	351.5	351.5	351.6	405.9	405.5	405.5	405.5	405.6
Replacement Energy [5]	DPS	27.7	28.2	36.4	38.5	39.3	47.1	53.4	59.2	71.3	79.5	89.5	106.9
	HYDRO	21.3	25.6	25.6	26.1	27.0	28.9	31.0	31.5	32.9	34.4	36.0	37.7
Replacement W/ Conservation [6]	C&LM	33.0	34.7	36.7	38.9	41.1	43.5	46.0	48.6	51.4	54.4	57.6	60.9
Fuel [7]	VY CO.	23.5	26.0	29.4	26.2	26.7	33.1	30.1	30.7	39.5	34.3	35.1	42.3
Hours in Year		8760	8760	8760	8784	8760	8760	8760	8784	8760	8760	8760	8784

NOTES:
[1] From Table 3.11, $ Million
[2] From Table 3.7, $ Million.
[3] Basis: Vermont Yankee - from Table 3.1.
National Data - from Table 3.3.
Vermont Yankee Co. - from Appendix f-2, F-3, VT DPS Technical Report 12.
[4] From Table 4.2 or 4.4 in $/KW.
[5] From Table 4.2 or 4.4 in $/MWH.
[6] Hypothetical conservation program; replacement power @ $30/MWH in 1987 $, inflated at DPS rates.
[7] From Appendix F-2, F-3 VT DPS Technical Report 12, $ Million at VTY Co. capacity factor.

TABLE 2.3: COST INPUTS

Input	BASIS	2001	2002	2003	2004	2005	2006	2007
Capital Additions [1]	VTY	24.5	26.0	27.6	29.3	31.1	33.0	35.0
	NAT	39.0	41.8	44.8	48.0	51.4	55.1	59.0
O&M [2]	VTY	131.9	144.2	157.5	171.9	187.4	204.1	222.1
	NAT	234.2	259.7	287.3	317.3	349.7	384.9	422.9
Capacity Factor [3]	VTY	68%	68%	79%	68%	68%	79%	68%
	NAT	56%	56%	67%	56%	56%	67%	56%
	VY CO.	77%	77%	91%	77%	77%	91%	77%
Replacement Capacity [4]	DPS	70.0	74.1	78.3	82.9	87.6	92.7	98.0
	HYDRO	404.2	405.2	404.1	404.9	405.1	420.6	422.2
Replacement Energy [5]	DPS	120.5	120.4	140.7	150.2	154.5	170.9	182.2
	HYDRO	39.5	41.4	43.5	45.6	47.8	50.2	52.7
Replacement W/ Conservation [6]	C&LM	64.4	68.1	72.0	76.2	80.6	85.2	90.2
Fuel [7]	VY CO.	36.7	37.6	45.2	39.5	40.4	48.7	43.0
Hours in Year		8760	8760	8760	8784	8760	8760	8760

TABLE 3.1: MATURE CAPACITY FACTORS, BASED ON VT YANKEE EXPERIENCE

	NEPOOL Winter Rating	DER		
Net Electrical Energy from 1/78 through 12/87 [1]:	32,216,261	32,216,261		
Hours [2]:	87,648	87,648		
Rated Capability [3]:	528	514		
Average Capacity Factor [4]:	69.61%	71.51%	Refueling Year [5]:	68.35%
			Non-refueling Year [5]:	78.88%

Notes: [1] Data through 1982 from Nuclear Power Plant Operating Experience, December, 1979 through January, 1985. Data after 1982 from Licensed Operating Reactors, January, 1984 through December, 1987.

[2] 8760 hours per year, 8784 hours in 1980 and 1984.

[3] From NEPOOL CELT Report, 1986, winter rating.

[4] Row [1] divided by Row [2], divided by Row [3].

[5] 71.51% adjusted to reflect the difference between refueling and non-refueling years. Vermont Yankee has refueled 7 times during the 10 years it has been in commercial operation.

W = non-refueling year capacity factor

W -.1053 = refueling year capacity factor

.1053 = the average of the refueling coefficients, Equations 3 and 4, Table 3.2.

$$71.51\% = 3/10*W + 7/10*(W - .1053)$$
$$71.51\% = W - 7/10*(.1053)$$
$$= W - .07371$$
$$W = 78.88\%$$
$$W - .1053 = 68.35\%$$

TABLE 3.2: RESULTS OF REGRESSIONS ON BWR CAPACITY FACTOR DATA, UNITS > 300 MW, 1972-1986

	Equation 1		Equation 2		Equation 3		Equation 4	
	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat
Constant	79.00%	7.78	82.90%	8.35	77.73%	7.642	81.71%	8.207
Size [1]	-2.75%	-2.28	-2.83%	-2.41	-2.63%	-2.176	-2.74%	-2.324
Age5 [2]	1.89%	1.90	1.54%	1.59	2.27%	2.379	1.87%	1.997
Refuel [3]	-10.47%	-4.04	-11.79%	-4.64	-9.91%	-3.852	-11.15%	-4.416
GT1000 [4]	4.54%	0.92	6.49%	1.35	4.23%	0.856	6.11%	1.266
Year Indicators [5]								
1979	6.32%	1.34	4.95%	1.07	---	---	---	---
1980	-0.84%	-0.18	-2.01%	-0.44	---	---	---	---
1981	-3.55%	-0.75	-4.82%	-1.04	---	---	---	---
1982	-5.15%	-1.07	-6.50%	-1.39	---	---	---	---
1983	-8.09%	-1.73	-9.47%	-2.08	---	---	---	---
1984	-14.65%	-3.17	-16.27%	-3.60	---	---	---	---
1985	-7.60%	-1.77	-9.58%	-2.28				
1986	-9.30%	-2.19	-11.14%	-2.68				
Post-1979 [6]	---	---	---	---	-8.87%	-3.384	-10.05%	-3.912
Adjusted R-SQ		0.118		0.133		0.109		0.123
F-Statistic		4.041		4.459		7.701		8.576
Observations		273	[7]	270		273	[7]	270

Notes: [1] SIZE = Design Electrical Rating (DER) in hundreds of MW.
[2] AGE5 = minimum of AGE (years from COD to middle of current year), or 5.
[3] Refuel = number of refuelings in year (usually 0 or 1).
[4] GT1000 = 1, if SIZE > 1000, 0 otherwise.
[5] Indicator = 1 in this year, 0 otherwise.
[6] 1980 or later.
[7] Excludes Browns Ferry 1975-76.

TABLE 3.3: PROJECTED BWR CAPACITY FACTOR FOR VERMONT YANKEE, BASED ON NATIONAL DATA

	Value of Refuel	Equation 3 Avg. Post-79 Conds.	Equation 4 [3] Avg. Post-79 Conds.	Average of Equations 3 and 4
Without Refueling [1]	0	66.67%	66.91%	66.79%
With Refueling [1]	1	56.76%	55.76%	56.26%
Mature Average Calculated from DER: [2]		60.06%	59.48%	59.77%
Mature Average Calculated from MDC: [4]		57.71%	57.14%	57.42%

Notes: [1] Calculated for a 514 MW DER unit with COD in November, 1972.
[2] Mature average reflects refueling in two out of three years.
[3] Equation 4 excludes the direct effects of the Brown's Ferry cable fire.
[4] DER capacity factor multiplied by DER/MDC (514/535).

TABLE 3.4: NON-FUEL O&M PROJECTIONS BASED ON VERMONT YANKEE EXPERIENCE ($1,000)

Results of Regression on Vt. Yankee O&M Data	
Constant	(233,110)
Year	3,262
R Squared	0.927

Year	Actual O&M Data for VT Yankee (nominal $)	Actual O&M Data for Vt. Yankee ($1983) [1]	Projection From Regression ($1983) [2]	Vermont's Share ($1983) [3]	Vermont's Share in Nominal Dollars [4]
1973	4,957	10,094	5,016		
1974	5,692	10,651	8,278		
1975	7,682	13,151	11,540		
1976	7,912	12,874	14,802		
1977	9,775	15,030	18,064		
1978	11,191	16,021	21,326		
1979	14,208	18,722	24,588		
1980	22,586	27,260	27,850		
1981	26,795	29,499	31,112		
1982	33,764	35,060	34,374		
1983	46,312	46,312	37,636		
1984	43,203	41,648	40,898		
1985	46,416	43,369	44,160		
1986	52,026	47,375	47,422		
1987			50,684		
1988			53,946	29,670	31,273
1989			57,208	31,464	34,769
1990			60,470	33,259	38,688
1991			63,732	35,053	43,128
1992			66,994	36,847	47,951
1993			70,256	38,641	53,187
1994			73,518	40,435	58,868
1995			76,780	42,229	65,027
1996			80,042	44,023	71,702
1997			83,304	45,817	78,929
1998			86,566	47,611	86,753
1999			89,828	49,405	95,216
2000			93,090	51,200	104,367
2001			96,352	52,994	114,257
2002			99,614	54,788	124,941
2003			102,876	56,582	136,478
2004			106,138	58,376	148,930
2005			109,400	60,170	162,364
2006			112,662	61,964	176,853
2007			115,924	63,758	192,474

Notes: [1] From FERC Form 1 or equivalent.
[2] O&M projections from the regression equation.
[3] Column [2] Multiplied by 55%, to calculate Vermont Yankee Co.'s share.
[4] Column [3] adjusted for inflation using DPS rates.

TABLE 3.5: RESULTS OF REGRESSIONS ON O&M DATA, ALL DOMESTIC LWR's, 1968-86

	Equation 1		Equation 2		Equation 3	
	[1]		[1]		[1]	
	Coef	t-stat	Coef	t-stat	Coef	t-stat
CONSTANT	-1.86	-7.77	-1.86	-7.77	-1.96	-8.52
ln(MW) [2]	0.52	22.11	--	--	--	--
ln(UNITS)	0.08	1.75	0.61	15.68	0.68	17.77
YEAR [3]	0.11	31.54	0.11	31.54	0.11	33.31
ln(MW/unit)	--	--	0.52	22.11	0.50	21.94
NE [4]	--	--	--	--	0.23	7.57
Adjusted R-sq.		0.84		0.84		0.86
F statistic		1171.5		1171.5		969.7

Notes: [1] The dependent variable in each equation is ln(non-fuel O&M in 1983$)
[2] MW = number of MegaWatts in MGN.
[3] YEAR = Calendar Year - 1900; e.g., 1985 = 85.
[4] NE is a dummy variable which measures whether the plant is located in the Northeast Region (defined as Handy Whitman's North Atlantic Region).
NE = 1 if located in Northeast Region, 0 if elsewhere.

TABLE 3.6: PROJECTED ANNUAL NON-FUEL O&M EXPENSE FOR VT YANKEE ($ 1,000)

Year	From Equation #3 (Table 3.5), Regression on National Data					
	Compound Real Growth			Linear Real Growth		
	$1983	Nominal	Vermont's Share	$1983	Nominal	Vermont's Share
	[1]	[2]	[3]	[4]	[5]	[6]
1988						
1989	$68,053	$71,639	$39,402	$68,053	$71,639	$39,402
1990	$75,865	$84,471	$46,459	$75,865	$84,471	$46,459
1991	$84,573	$99,600	$54,780	$83,676	$98,544	$54,199
1992	$94,281	$117,440	$64,592	$91,488	$113,961	$62,678
1993	$105,103	$138,474	$76,161	$99,299	$130,828	$71,955
1994	$117,167	$163,276	$89,802	$107,111	$149,262	$82,094
1995	$130,616	$192,521	$105,886	$114,922	$169,389	$93,164
1996	$145,609	$227,003	$124,852	$122,734	$191,340	$105,237
1997	$162,323	$267,661	$147,214	$130,545	$215,262	$118,394
1998	$180,956	$315,602	$173,581	$138,357	$241,306	$132,718
1999	$201,727	$372,129	$204,671	$146,169	$269,640	$148,302
2000	$224,883	$438,781	$241,330	$153,980	$300,439	$165,242
2001	$250,696	$517,372	$284,554	$161,792	$333,896	$183,643
2002	$279,473	$610,038	$335,521	$169,603	$370,213	$203,617
2003	$311,553	$719,302	$395,616	$177,415	$409,609	$225,285
2004	$347,315	$848,136	$466,475	$185,226	$452,319	$248,776
2005	$387,182	$1,000,045	$550,025	$193,038	$498,595	$274,227
2006	$431,625	$1,179,163	$648,539	$200,850	$548,704	$301,787
2007	$481,170	$1,390,362	$764,699	$208,661	$602,936	$331,615

Notes: [1] MW=563, NE = 1, Units = 1.
[2], [5] Escalated using DPS inflators.
[3], [6] Nominal value multiplied by 55%, Vermont's share of Vermont Yankee.
[4] From 1990, projections increase by difference between 1989 and 1990.

TABLE 3.7: SUMMARY OF PROJECTED NON-FUEL O&M EXPENSE FOR VT'S SHARE OF VT YANKEE ($ 1,000)

Basis: Year	Vt Yankee ($1983) [1]	National ($1983) [2]	Vt Yankee ($ Nominal) [3]	National ($ Nominal) [4]
1989	31,464	37,429	34,769	39,402
1990	33,259	41,725	38,688	46,459
1991	35,053	46,022	43,128	54,199
1992	36,847	50,318	47,951	62,678
1993	38,641	54,615	53,187	71,955
1994	40,435	58,911	58,868	82,094
1995	42,229	63,207	65,027	93,164
1996	44,023	67,504	71,702	105,237
1997	45,817	71,800	78,929	118,394
1998	47,611	76,096	86,753	132,718
1999	49,405	80,393	95,216	148,302
2000	51,200	84,689	104,367	165,242
2001	52,994	88,985	114,257	183,643
2002	54,788	93,282	124,941	203,617
2003	56,582	97,578	136,478	225,285
2004	58,376	101,875	148,930	248,776
2005	60,170	106,171	162,364	274,227
2006	61,964	110,467	176,853	301,787
2007	63,758	114,764	192,474	331,615

Notes: [1] From Column [2], Table 3.4.
[2] Column [4], Table 3.6 * 55%
[3] From Column [4], Table 3.4.
[4] Column [6], Table 3.6.

TABLE 3.9: NET CAPITAL ADDITIONS EXPERIENCE FOR VERMONT YANKEE ($ 1,000)

Year	Plant Cost [1]	Nominal $	$1983 [2]	$/kw [3]
1972	172,042	-	-	-
1973	184,481	12,439	28,237	50.15
1974	185,158	677	1,348	2.39
1975	185,739	581	1,038	1.84
1976	193,886	8,147	13,598	24.15
1977	196,331	2,445	3,801	6.75
1978	198,837	2,506	3,670	6.52
1979	200,835	1,998	2,668	4.74
1980	217,575	16,740	20,652	36.68
1981	226,115	8,540	9,693	17.22
1982	231,880	5,765	6,031	10.71
1983	255,209	23,329	23,329	41.44
1984	259,856	4,647	4,489	7.97
1985	272,185	12,329	11,565	20.54
1986	326,070	53,885	50,131	89.04
Average:		11,002	12,875	22.87
1980's Average:		17,891	17,984	31.94

Notes: [1] From FERC Form 1, or equivalent.
[2] Deflated at Handy Whitman Index.
[3] Based on MGN Rating (563 MW).

TABLE 3.9: NUCLEAR CAPITAL ADDITIONS, 1972-1986

Year	All Plants	Single units, 300-800 MW	Single units, > 800 MW
	Averages by Year (in $/kw-yr)		
1972	5.81	1.92	-
1973	10.87	8.18	38.9
1974	11.07	8.54	26.82
1975	8.72	3.18	19.76
1976	15.49	19.69	5.89
1977	19.90	32.86	12.76
1978	17.77	19.10	25.94
1979	14.83	20.39	16.76
1980	27.73	37.53	27.97
1981	33.03	42.48	34.08
1982	29.09	45.04	24.8
1983	30.45	56.38	26.46
1984	42.08	84.91	36.07
1985	25.41	25.49	22.36
1986	34.84	53.78	28.76
Overall Average:	22.37	30.60	24.1
(# of obs.)	617	192	150
1978-1986 Average:	27.87	43.08	26.92
(# of obs.)	314	90	92
1980-1986 Average:	31.83	48.82	28.33
(# of obs.)	322	90	91

TABLE 3.10: PROJECTED NET CAPITAL ADDITIONS FOR VERMONT YANKEE, BASED ON NATIONAL DATA ($ 1,000)

Regression Equation for Capital Additions per Unit

Constant	-31498	If80	11,032
		If81	13,998
ln(MW per unit)	6650	If82	11,411
		If83	12,891
ln(Units)	-10373	If84	21,776
		If85	11,938
		If86	17,554
		Avg. 1980-86	14,371

Real Cost Projections (1983 $), 1 Unit, 563 MW (MGN Rating), 1980's Conditions: $24,992

Vermont's Share: $13,746

Year	Nominal Capital Additions	Vermont's Share
	[1]	[2]
1989	$31,238	$17,181
1990	$33,306	$18,318
1991	$35,677	$19,622
1992	$38,217	$21,020
1993	$40,939	$22,516
1994	$43,853	$24,119
1995	$46,976	$25,837
1996	$50,320	$27,676
1997	$53,903	$29,647
1998	$57,741	$31,758
1999	$61,852	$34,019
2000	$66,256	$36,441
2001	$70,974	$39,035
2002	$76,027	$41,815
2003	$81,440	$44,792
2004	$87,239	$47,981
2005	$93,450	$51,397
2006	$100,104	$55,057
2007	$107,231	$58,977

[1] 1983 Calculation escalated by Handy-Whitman inflator through 1987, and with DPS escalators plus 1.35% (the historical difference between implicit GNP deflator and H-W deflators, 1970-1987) thereafter.
[2] 55% of Column [1].

TABLE 3.11: SUMMARY OF PROJECTED CAPITAL ADDITIONS COSTS, VT'S SHARE OF VT YANKEE ($ 1,000,000)

	Basis:	Vermont	National
	Year	Nominal $	Nominal $
		[1]	[2]
Capital Additions in $1983:		$9.89	$13.75
	1989	$12.07	$17.18
	1990	$12.75	$18.32
	1991	$13.53	$19.62
	1992	$14.36	$21.02
	1993	$15.24	$22.52
	1994	$16.17	$24.12
	1995	$17.16	$25.84
	1996	$18.21	$27.68
	1997	$19.32	$29.65
	1998	$20.51	$31.76
	1999	$21.76	$34.02
	2000	$23.09	$36.44
	2001	$24.50	$39.04
	2002	$26.00	$41.81
	2003	$27.60	$44.79
	2004	$29.28	$47.98
	2005	$31.08	$51.40
	2006	$32.98	$55.06
	2007	$35.00	$58.98

Notes: [1] From Table 3.8: $31.94/kw *.55*563 MW/1000, escalated by the Handy-Whitman inflator through 1987, and with DPS inflators plus 1.35% (the average difference between the implicit GNP deflator and H-W deflators, 1970-1987) thereafter. 310 MW = .55 * 563 (Vermont MGN rating).

[2] From Table 3.10. Projection based on regression of national data.

TABLE 3.12: ANALYSIS OF OVERHEAD EXPENSE FOR VERMONT YANKEE ($ 1,000)

		1981	1982	1983	1984	1985	1986		Averages:
1. Total O&M		$52,967	$72,201	$73,140	$73,673	$77,454	$80,084		
2. Other O&M		4,038	6,812	8,080	9,021	10,267	12,592		
3. Employment Taxes:	Est	411	478	583					
FICA					620	724	840		
Fed. Unemp.					16	45	20		
State Unemp.					44	48	52		
4. Total Other		4,449	7,290	8,663	9,701	11,084	13,504		
5. Station O&M		48,929	65,489	65,060	64,652	67,187	67,491		
6. Fuel		22,134	31,725	18,750	21,449	20,771	15,465		
7. Non-fuel Station O&M		26,795	33,764	46,310	43,203	46,416	52,026		
8. Other as a % of Non-fuel Station O&M		16.60%	21.59%	18.71%	22.45%	23.88%	25.96%	1981-86:	21.53%
								1984-86:	24.10%

Source:
Vermont Yankee FERC Forms, 1984-86, and Financial Statistics 1981-83.

Notes:
[1]: p. 323, line 168.
[2]: [1]-[5]
[3]: p. 258. If not available, 7% of salary and wages.
[4]: [2]+[3]
[5]: p. 402, line 34. (should equal p. 320, line 40)
[6]: p. 320, line 24, or p. 402, line 21.
[7]: [5]-[6]
[8]: [4]/[7]

TABLE 4.1: DEFICIENT CAPACITY RESULTING FROM CLOSURE OF VT YANKEE

Winter Starting:	Vermont Existing & Committed Capacity	Vermont Yankee Entitlement	Existing & Committed Capacity Net VT Yankee	Vermont Peak Load	Required Reserves	Required Capacity	Deficiency
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
1988	1266.6	286	980.6	936	14.2%	1068.9	88.3
1989	1262.8	286	976.8	942	12.2%	1056.9	80.1
1990	1265.8	286	979.8	950	12.2%	1065.9	86.1
1991	1273.3	286	987.3	959	12.2%	1076.0	88.7
1992	1280.7	286	994.7	968	12.2%	1086.1	91.4
1993	1288.2	286	1002.2	978	12.2%	1097.3	95.1
1994	1295.6	286	1009.6	987	12.2%	1107.4	97.8
1995	1295.6	286	1009.6	995	12.2%	1116.4	106.8
1996	1295.6	286	1009.6	1004	12.2%	1126.5	116.9
1997	1289.5	286	1003.5	1013	12.2%	1136.6	133.1
1998	1212.5	286	926.5	1022	12.2%	1146.7	220.2
1999	1212.5	286	926.5	1032	12.2%	1157.9	231.4
2000	1212.5	286	926.5	1041	12.2%	1168.0	241.5
2001	1212.5	286	926.5	1050	12.2%	1178.1	251.6
2002	1212.5	286	926.5	1060	12.2%	1189.3	262.8
2003	1212.5	286	926.5	1069	12.2%	1199.4	272.9
2004	1212.5	286	926.5	1078	12.2%	1209.5	283.0
2005	1212.5	286	926.5	1088	12.2%	1220.7	294.2
2006	1212.5	286	926.5	1098	12.2%	1232.0	305.5

Notes:
[1], [2], [4]: DPS filing, PSB Docket 5177
[3]: [1]-[2]
[5]: From NEPOOL presentation to New England Governors' Conference, 7/24/86. Reduced by 7.2% to reflect historical difference between Vermont and NEPOOL required reserves.
[6]: [4]*(1+[5])
[7]: [6]-[3]

TABLE 4.2: PROJECTED SMALL POWER PRODUCER REPLACEMENT COSTS

Year	Capacity Costs ($/KW)	Energy Costs $/MWH
1989	$26.12	$27.71
1990	$29.02	$28.23
1991	$36.76	$36.41
1992	$42.26	$38.51
1993	$44.70	$39.31
1994	$47.28	$47.14
1995	$50.01	$53.39
1996	$52.89	$59.22
1997	$55.95	$71.34
1998	$59.17	$79.47
1999	$62.59	$89.50
2000	$66.20	$106.85
2001	$70.02	$120.47
2002	$74.06	$120.39
2003	$78.33	$140.74
2004	$82.85	$150.19
2005	$87.63	$154.45
2006	$92.69	$170.88
2007	$98.04	$182.20

Source: Energy Costs from VDPS Filing, Docket #5177, at generation level. Capacity costs from Table 4.3.

Table 4.3: LEVELIZING CAPACITY COSTS IN REAL TERMS

Year	$1 escalated @ 5.77%	$1 level	5.77% escalation w/ PV of $1 level	$89.11 real levelized at 5.77%	DPS Peaker cost $/kw-year	Year	VDPS inflation index	New GT	VDPS Purchase Price	Assumed Peaker cost $/kw-year	Cost at Generation Level $/kw-year
	[1]	[2]	[3]	[4]	[5]		[6]	[7]	[8]	[9]	[10]
						1989	114.77	$42.04	$30.60	$30.60	$26.12
						1990	120.82	$44.26	$34.00	$34.00	$29.02
						1991	127.79	$46.81	$43.07	$43.07	$36.76
						1992	135.17	$49.51	$54.40	$49.51	$42.26
						1993	142.96	$52.37	$69.13	$52.37	$44.70
1	1	1	0.6216	$55.39	$89.11	1994	151.21	$55.39	NA	$55.39	$47.28
2	1.0577	1	0.6574	$58.58	$89.11	1995	159.94	$58.58	NA	$58.58	$50.01
3	1.1187	1	0.6954	$61.96	$89.11	1996	169.17	$61.96	NA	$61.96	$52.89
4	1.1833	1	0.7355	$65.54	$89.11	1997	178.93	$65.54	NA	$65.54	$55.94
5	1.2516	1	0.7779	$69.32	$89.11	1998	189.25	$69.32	NA	$69.32	$59.17
6	1.3238	1	0.8228	$73.32	$89.11	1999	200.17	$73.32	NA	$73.32	$62.59
7	1.4002	1	0.8703	$77.55	$89.11	2000	211.72	$77.55	NA	$77.55	$66.20
8	1.4809	1	0.9205	$82.03	$89.11	2001	223.94	$82.03	NA	$82.03	$70.02
9	1.5664	1	0.9736	$86.76	$89.11	2002	236.86	$86.76	NA	$86.76	$74.06
10	1.6568	1	1.0298	$91.76	$89.11	2003	250.53	$91.76	NA	$91.76	$78.33
11	1.7524	1	1.0892	$97.06	$89.11	2004	264.98	$97.06	NA	$97.06	$82.85
12	1.8535	1	1.1520	$102.66	$89.11	2005	280.27	$102.66	NA	$102.66	$87.63
13	1.9604	1	1.2185	$108.58	$89.11	2006	296.44	$108.58	NA	$108.58	$92.59
14	2.0735	1	1.2888	$114.85	$89.11	2007	313.55	$114.85	NA	$114.85	$98.03
15	2.1932	1	1.3632	$121.47	$89.11						
16	2.3197	1	1.4418	$128.48	$89.11						
17	2.4536	1	1.5250	$135.90	$89.11						
18	2.5952	1	1.6130	$143.74	$89.11						
19	2.7449	1	1.7061	$152.03	$89.11						
20	2.9033	1	1.8046	$160.80	$89.11						
21	3.0708	1	1.9087	$170.08	$89.11						
22	3.2480	1	2.0188	$179.90	$89.11						
23	3.4354	1	2.1353	$190.28	$89.11						
24	3.6336	1	2.2585	$201.25	$89.11						
25	3.8433	1	2.3888	$212.87	$89.11						
PV 25 yrs	14.0598	8.7390	8.7390	$778.73	$778.73						
PV to 2007 (in 1993$ @ 10.5%)				$536.30	$638.93						

Notes:
[1]: Inflation rate from DPS filing, PSB 5177. Also used in GMP Vermont Yankee Study, 10/8/87.
[3]: [1]/PV[2]/PV[1]
[4]: [3] * $89.11
[5], [6], [8]: DPS filing, PSB 5177, Costs are at primary level.
[7]: column [4] deflated by column [6].
[9]: minimum of purchase price ([8]) and new Peaker cost ([4] or [7]).
[10]: [9]/1.1715, to remove primary-load losses assumed by DPS.

Table 4.4: PROJECTED HYDRO QUEBEC REPLACEMENT COSTS

Year	Capacity Cost ($/KW)	Energy Costs ($/MWH)
1989	$251.56	$21.33
1990	$149.02	$25.62
1991	$194.32	$25.62
1992	$313.55	$26.12
1993	$351.51	$27.01
1994	$351.48	$28.93
1995	$351.56	$30.98
1996	$405.85	$31.47
1997	$405.52	$32.90
1998	$405.50	$34.43
1999	$405.51	$36.04
2000	$405.55	$37.74
2001	$404.16	$39.53
2002	$405.15	$41.43
2003	$404.11	$43.45
2004	$404.88	$45.58
2005	$405.10	$47.84
2006	$420.62	$50.22
2007	$422.21	$52.74

Source: Winooski Hydroelectric, Schedule B assumed for 1989.
Assumes DPS inflation, losses only for HQ line and converter.

APPENDIX 1:

"Depreciating Nuclear Power Plants"

DEPRECIATING NUCLEAR POWER PLANTS

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I. Introduction and Statement of the Problem

Most U.S. electric utilities with operating nuclear power plants are currently under-recovering in their rates for nuclear decommissioning expense and for nuclear plant depreciation. This results from two separate, but inter-active, mis-estimates. First, most owner/operators use optimistic estimates of total decommissioning expense (i.e., of net negative salvage value), which causes decommissioning expense provisions in depreciation expenses, and thus total depreciation accruals, to be too low. Second, most owner/operators use optimistic estimates of total (and remaining) useful service lives, which causes depreciation rates, ex-penses, and total accruals to be two low. These two prac-tices in turn cause electric utilities with nuclear power plants to have current rates, gross revenues, net income, and internally-generated cash flows that are lower than they would be otherwise.

Electric utilities have tended to use decommissioning expense estimates of roughly $75 M - $150 M (in 1986 $), or about $75 to $150 per KW (in 1986 $) for a 1000 MW unit. These traditional estimates have been based upon early eng-ineering cost estimate studies. Similarly, electric util-ities have tended to use assumptions for nuclear power plants' useful service lives of 38-40 years, which were in turn taken from assumptions used in NRC licensing cases. Electric utilities were not averse to using optimistic decommissioning expense estimates and optimistic useful ser-vice life estimates in general, because the primary initial use of these estimates was in proceedings designed to jus-tify nuclear power plant construction, such as NRC licensing proceedings, state certification of need proceedings, or state proceedings to determine the prudence of generation planning decisions.

This paper looks at likely decommissioning expense est-imates in Section II and at likely useful service life est-imates in Section III. Limitations and warnings are stated in Section IV. Conclusions are stated in Section V. In general, it is concluded that (unless there are overwhelming concerns about loss of load due to price elasticity effects) most U.S. electric utilities with nuclear power plants should raise their provisions in rates for nuclear decommissioning expenses and for nuclear depreciation expenses. References are listed in Section VI and the data base for Section III is listed in summary form in Appendix A.

II. Decommissioning Expense Amount

Traditional engineering cost estimates have been produced for several U.S. commercial nuclear power plants. In addition, Battelle Pacific Northwest has produced two widely cited decommissioning cost estimates for the NRC for a reference PWR (ref. (1)) and for a reference BWR (ref. (2)). These two studies produced cost estimates (in 1978 $) for the reference plants as shown below in Table 1.

Table 1: Battelle Pacific Northwest
Decommissioning Cost Estimates

1155 MW BWR, immediate dismantlement	$43.6M
1155 MW BWR, storage & deferred dismantlement	$58.8M
1155 MW BWR, entombment	$40.6M
1175 MW PWR, immediate dismantlement	$42.1M
1175 MW PWR, storage & deferred dismantlement	$46.8M-$51.8M

Let us focus on the immediate dismantlement alternative because that appears to be the NRC-favored alternative. The $43.6M and the $42.1M estimates (in 1978 $) are roughly equivalent to estimates of $69M and $66M, respectively, in 1986 $, using a GNP deflator of 1.575. More recent estimates by owner/operators for specific plants have generally tended to cluster around the range of $110M to $130M in 1986 $ for a nuclear plant in the 1,000 MW to 1,150 MW size range.

Despite these relatively optimistic decommissioning cost estimates, there is substantial reason to believe that the actual decommissioning costs will be higher by a factor of about two to five in constant dollar terms. Estimates of past error rates in U.S. commercial nuclear power plant construction cost estimates are about 10% per year above inflation. Applying these past error rates to decommissioning projects that will occur twenty years or more in the future implies (if no moderation occurs) that current estimates are low by a factor of at least five. If one assumes that past error rates in commercial nuclear power plant construction cost estimates (which were remarkably persistent over a period of at least twenty years) would moderate in the future for decommissioning cost estimates, then current decommissioning cost estimates might nevertheless be low by a factor of two in constant dollar terms. It must be emphasized that decommissioning cost estimates have already begun to show the same persistent and robust growth in constant dollar terms that construction cost estimates have shown in the past. See ref. (3), pp. 110-123, and ref. (4).

In sum, the current plant-specific decommissioning cost estimates, which tend to cluster around and slightly above $100 per KW in 1986 $, are probably best viewed as being too low by a factor of two to five in constant dollar terms. For financial planning purposes, electric utilities with nuclear power plants should probably use decommissioning cost estimates in the range of $200 to $500 per KW in 1986 $.

III. Depreciation Rate: Useful Service Life

In order to produce a depreciation reserve that matches tangible property's original cost at the time of that property's retirement, one needs an accurate before-the-fact estimate of the property's useful service life. This section of this paper describes an attempt to estimate (on a before-the-fact basis) the expected useful service life of a U.S. LWR, based upon actual experience to date. The purpose of this exercise is to determine whether or not the relatively arbitrary assumptions about useful service lives that are currently in widespread use are consistent with actual data.

A. The Data Sets

Three data sets of U.S. light water reactors were constructed. For all three data sets, no distinction was made between PWRs and BWRs. For all three data sets, other types of technologies were excluded: breeders, gas-cooled, and graphite-moderated reactors, for example, were excluded. This decision excluded such commercial U.S. reactors as Fort St. Vrain, Peach Bottom 1, and Fermi 1 from this analysis.

Having made the decision to focus on all U.S. LWRs, two further definitions were made. First, a distinction was made between reactors that were "commercial in intent" and reactors which were "non-commercial in intent." "Commercial in intent" was defined to include reactors which were intended to be dispatched commercially for a substantial amount of time, whether or not the reactor was also intended to serve certain research goals. "Non-commercial in intent" was defined to include those reactors which were intended primarily or exclusively to serve research goals. Second, a distinction was drawn between reactors which were "commercial in design" and those which were "non-commercial in design." "Commercial in design" was defined as including all LWRs over 400 MW, while "non-commercial in design" was defined as including all LWRs under 400 MW.

The first, and least inclusive, data set, Data Set 1, was comprised of all U.S. LWRs which had entered commercial operation before December 31, 1985 and which were both "commercial in intent" and "commercial in design." Data Set 1 included 88 units, with the oldest (San Onofre 1) having entered commercial operation in 7/67 and the newest (Diablo Canyon 2) having entered commercial operation in 10/85. Only one of the 88 units in Data Set 1 was considered to have completed its useful service life for the purposes of this study: Three Mile Island 2, which entered commercial operation in 4/78 and which ceased commercial operation in 3/79.

The second data set, Data Set 2, includes all 88 units in Data Set 1, and additionally includes all 6 U.S. LWRs which were "commercial in intent" but "non-commercial in design." Data Set 2 thus included 94 units, with the six additions to Data Set 1 being Dresden 1, Yankee Rowe, Indian Point 1, Big Rock Point, Humboldt Bay, and LaCrosse. Three of these six additional units (Dresden 1, Indian Point 1, and Humboldt Bay) have been retired.

The third data set, Data Set 3, is the most inclusive. It includes all 94 units in Data Set 2, and additionally includes all four U.S. LWRs that were "non-commercial in intent" as well as "non-commercial in design." These four additional units were Shippingport, Elk River, BONUS, and Pathfinder. All four of these additional units are retired.

These three data sets are summarized in Table 2, below.

Table 2: Data Set Summary

Data Set	Includes All U.S. LWRs Which Were		LWRs in Data Set	LWRs Retired
	Design	Intent		
Data Set 1	Commercial	Commercial	88	1
Data Set 2	Commercial or Non-Comm.	Commercial	94	4
Data Set 3	Commercial or Non-Comm.	Commercial or Non-Comm.	98	8

B. Results

Analyzing the three data sets produces some evidence that useful service lives are likely (but not certain) to be shorter than the currently-assumed 38-40 year useful service lives. This is the result, whether one uses such traditional depreciation rate calculation methods as Iowa curves (refs. (5), (6), and (7)) or more modern statistical methods as product-limit estimates or reduced-set estimates (ref. (8), ch. 4). For the three defined data sets, and for the two estimation methods applied to estimate useful service lives, Table 3 below shows the estimates which seem most consistent with the data.

Table 3: Useful Service Life Estimates

Data Set	Product-Limit Estimate	Reduced-Set Estimate
Data Set 1	25 years or more	25 years or more
Data Set 2	25 - 35 years	20 - 30 years
Data Set 3	20 - 30 years	20 - 30 years

Two points should be made here. First, the data is very sparse. Differences in the estimates between the data sets (holding the estimation method constant) and between the estimation methods (holding the data sets constant) may only reflect random events, and not any real underlying phenomenon. Second, one pattern that appears to emerge in the data is that the less inclusive data sets produce more optimistic estimates than the more inclusive data sets. For example, Data Set 1 is clearly consistent with 40 year lives while Data Sets 2 and 3 do not appear to be consistent with 40 year lives. Whether this is an artifact in the data sets (the oldest unit in Data Set 1 is 19.1 years old) or a real phenomenon (truly commercial units, having somewhat different designs and greater economic value, may be less subject to obsolescence) is not clear at this point.

What is clear is that the data is currently providing weak indications that somewhat shorter useful service lives than the arbitrary 38-40 year assumptions may be appropriate for financial reporting and ratemaking purposes.

IV. CAVEATS

Before stating any conclusions, five caveats seem important.

First, both decommissioning expense amounts and useful service lives are heavily dependent upon NRC regulation. Actions by the NRC to change worker radiation exposure limits (for example) would cause major changes in decommissioning costs. Similarly, actions by the NRC to change "backfitting" requirements (and thus to change one major cause of capital additions) would cause changes in useful service lives by changing the pressures of economic obsolescence, all other things being equal.

Second, useful service lives are heavily dependent upon oil prices and other fossil fuel prices. Economic obsolescence, and hence retirements, are more likely sooner in a world of continued low oil prices and other fossil fuel prices than in a world that reverts to high oil and other fossil fuel prices, all other things being equal.

Third, the data is very sparse to date, and inferences which can be drawn from the data are consequently also weak, in the area of useful service lives. Sparse data only permit relatively weak inferences, with relatively wide confidence intervals. Similarly, the sparseness of the data means that a small amount of future data may modify the best current estimates substantially. A few years of additional experience with no additional retirements will cause best estimates of useful service lives to increase substantially. Similarly, a few retirements in the near future will cause best estimates of useful service lives to decrease substantially.

Fourth, with respect to estimation methods used for estimating decommissioning expense amounts, the estimation methods themselves are somewhat suspect. The traditional engineering cost estimate method, which estimates material and labor quantities from engineering drawings, multiplies them by material and labor cost rates, respectively, and then adds a nominal contingency amount, has proved to be persistently biased on the low side when applied to commercial nuclear power plant construction cost estimation. Whether the traditional engineering cost estimate methodology will prove to be similarly biased when applied to nuclear decommissioning projects is somewhat problematic. However, there are early indications over the past eight years that a similar phenomenon is occurring with respect to decommissioning cost estimates. Applying past error rates of traditional engineering cost estimates (ref. (3), pp. 110-123; ref. (4)) to current engineering cost estimates provides one reasonable sensitivity test that may well prove prophetic. Nevertheless, the models themselves in this area are all necessarily quite weak.

Fifth, all considerations of decommissioning expense amount estimation and of useful service life estimation must be tempered by considerations relating to the total delivered price of electricity before they are adopted in rates. Financial stability considerations argue strongly against undersetimating decommissioning expense or overestimating useful service lives in rates. However, at some point, competitive pressures from near-substitutes for electricity (oil, natural gas, conservation and load management, etc.) dictate that financial considerations be tempered with loss of load and loss of sales considerations. Utilities that are particularly vulnerable to losing industrial load, for example, may wish to underestimate nuclear depreciation expenses in rates for the time being. If this is the case, however, this should be done only after a conscious decision is made, and continued scrutiny should be exercised so that the decision is explicitly reviewed periodically.

V. Conclusions

There is some reason to believe that current nuclear decommissioning cost estimates and current nuclear useful service life estimates are too optimistic. The evidence for this is weak, and the inferences that are properly drawn from the experience to date are similarly weak. Nevertheless, prudent financial planning would seem to require that some upwards revisions in rates be made now to decommissioning cost and depreciation rate provisions. Additionally, owner/operators of nuclear power plants should subject the relevant data to serious scrutiny over the next few years to determine if the current "early warning indications" are in fact borne out by subsequent experience.

VI. References

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Appendix A: The Data Sets and Results

Data Set 1
Product-Limit Estimates

Years of Service	Surviving %
0.0-0.8	100.0%
0.9-19.1	98.9%
over 19.1	no data

Data Set 2
Product-Limit Estimates

Years of Service	Surviving %
0.0-0.8	100.0%
0.9-12.0	98.9%
12.1-13.2	96.5%
13.3-18.3	92.8%
18.5-25.7	74.2%
over 25.7	no data

Data Set 3
Product-Limit Estimates

Years of Service	Surviving %
0.0-0.8	100.0%
0.9-1.1	99.0%
1.3-3.7	97.9%
3.8-3.9	96.7%
4.5-12.0	95.4%
12.1-13.2	93.2%
13.3-18.3	89.7%
18.5-23.7	74.8%
25.3-25.7	37.4%
over 25.7	no data

Data Set 1
Reduced-Set Estimates

Years of Service	Surviving %
0.0-0.7	100%
0.9-8.3	98%
8.4-19.0	100%
over 19.0	no data

Data Set 2
Reduced-Set Estimates

Years of Service	Surviving %
0.0-0.7	100%
0.9-8.3	98%
8.4-11.9	100%
12.1-12.6	97%
12.8-13.2	96%
13.3-13.7	92%
13.8-13.9	91%
14.0-14.2	90%
14.3	89%
14.6-15.0	88%
15.3	87%
15.7	86%
15.8	84%
16.3	83%
16.6	81%
16.7	80%
16.8	77%
18.3	75%
18.5	62%
18.9	57%
19.0	50%
23.3	40%
23.6	50%
23.8	33%
25.7	50%
26.3	0%
over 26.3	no data

Data Set 3
Reduced-Set Estimates

Years of Service	Surviving %
0.0-0.7	100%
0.9-1.2	98%
1.3-3.7	97%
3.8	96%
4.5	95%
4.6-8.3	94%
8.4-10.2	95%
10.3-11.8	94%
11.9	93%
12.1	91%
12.2-12.6	90%
12.8	89%
12.9-13.1	88%
13.2	87%
13.3-13.7	83%
13.8	82%
13.9	81%
14.0	80%
14.2	79%
14.3	78%
14.6	77%
15.0	76%
15.3	75%
15.7	73%
15.8	70%
16.3	68%
16.6	66%
16.7	64%
16.8	61%
18.3	58%
18.5	53%
18.9	45%
19.0	40%
20.0	33%
21.9	37%
22.9	42%
23.3	50%
23.6	60%
23.8-25.3	50%
25.7	33%
26.3	0%
29.4	50%
over 29.4	no data