Stranded Nuclear Waste

Implications of Electric Industry Deregulation for Nuclear Plant Retirements and Funding Decommissioning and Spent Fuel

By
Bruce Biewald and David White
Synapse Energy Economics, Inc.

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Synapse Energy Economics, Inc., 22 Crescent Street, Cambridge, MA 02138
617-661-3248; fax 617-661-0599; www.synapse-energy.com

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1. Introduction and Summary

1.1. Introduction

This paper summarizes the results of an integrated three-part project dealing with: (1) the prospects for early nuclear power plant closure, (2) the potential unfunded liability for decommissioning, and (3) the potential unfunded liability for spent nuclear fuel transportation and storage. This is all considered in the context of electric industry dergulation.

When utilities and regulators determine funding amounts for decommissioning it is typically assumed without question that the nuclear generator will continue to produce electricity until the end of its 40-year operating license. Similarly, for determining funding adequacy for the high-level waste disposal program, the Department of Energy typically assumes that all reactors will run to (or nearly to) the end of their operating licenses. This faith in the longevity of existing nuclear power plants is unfounded, inconsistent with nuclear experience to date, and can lead to imprudent and inefficient decision-making.

1.2. Nuclear Scenarios

Based upon our comparison of nuclear unit operating costs with projected market prices for electricity, we have developed three projections of nuclear unit retirements. The High, Reference, and Low Nuclear Generation cases have 20, 34, and 90 nuclear units retiring prior to the end of their operating licenses.[1] In each case, the average shutdown for the units closed "prematurely" is about 15 years prior to the end of the license.

1.3. Decommissioning Funding Shortfalls

We estimate that for the fleet of currently operating nuclear power plants, the investor-owned utilities' portion of the unfunded liability for decommissioning is about $24 billion, at year end 1997 in 1997 dollars. If all of the units operate to the end of their licenses and the decommissioning cost estimates turn out to be correct, then the full amount needed for decommissioning could be collected during the units' operating period. However, with early retirements, we estimate the unfunded decommissioning liability at the time of closure, summed for all of the units projected to be retired early, to total $4.1 billion, $7.1 billion, and $15.3 billion in 1997 dollars for the High, Reference, and Low Nuclear Generation cases, respectively.

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[1] Out of a total of 102 currently operating nuclear units. Note that the "High Nuclear Generation" case is the one with assumptions favorable to continued operation of the nuclear units, and so has a low number of early nuclear retirements. Conversely, the "Low Nuclear Generation" case has the highest number of early nuclear retirements.

1.4. Spent Fuel Funding Shortfalls

We find that the prospect of plant retirements reducing the revenue stream to fund the disposal of spent nuclear fuel suggests that the current one mill per kWh fee collected by DOE should be increased. Even more significantly, the DOE's cost estimate for implementing the spent fuel disposal program appears to be out-of-date and optimistic. If a recent independent cost assessment putting the total program cost roughly 50% above DOE's estimate is correct, then the fee (in nominal dollars) may have to be increased to something in the range of 2.6 mills per kWh (for the EIA generation projection) to 4.5 mills per kWh (with the Synapse low case nuclear generation projection).

These required increases, however, could result in additional nuclear retirements. For example, with the Synapse Reference Case for nuclear retirements and the independent cost estimate for the waste disposal program, we find that the fee increase from one to 2.9 mills per kWh can be expected to result in the early retirement of an additional ten nuclear units. This would, in turn, cause a need to further increase the fee. It appears that the high level waste disposal program may not be able to simultaneously satisfy both of its principles.[2] This potential conflict should be recognized, and avoided to the extent possible by timely adjustments to the fee. To the extent that required prospective fee increases are not feasible due to the feedback effect upon nuclear generation, other funding approaches, such as retroactive assessments upon the generators of the waste may be necessary.

[2] The funding of the high level waste disposal program is to be paid by the owners and generators of spent nuclear fuel through a fee paid to the DOE for nuclear kWh generated and sold, and at the same time the fee is not to be changed retroactively.

2. Nuclear Generation Projections

2.1. Recent Nuclear Generator Retirements

One need only consider the list of units that have shutdown before the end of their operating licenses to realize that "premature" closure – retirement prior to the expiration of the operating license – is more than a remote possibility. Table 2.1 lists the nuclear power plants in the US that have been retired, or for which shutdown has been announced.

Table 2.1 Retired Nuclear Generating Units With Capacity 40 MW and Larger

Plant	State	Capacity (MWe)	Year Closed	Approximate Age at Retirement (years)
Hallam	Nebraska	75	1964	2
Pathfinder	South Dakota	66	1967	3
Fermi 1	Michigan	61	1972	9
Indian Point 1	New York	265	1974	12
Peach Bottom 1	Pennsylvania	40	1974	8
Humboldt Bay	California	65	1976	14
Dresden 1	Illinois	200	1978	19
Three Mile Island 2	Pennsylvania	926	1979	1
Shippingport	Pennsylvania	72	1982	25
La Crosse	Wisconsin	48	1987	19
Rancho Seco	California	918	1989	15
Shoreham	New York	820	1989	0
Fort St. Vrain	Colorado	330	1989	10
San Onofre 1	California	436	1992	25
Yankee Rowe	Massachusetts	175	1992	31
Trojan	Oregon	918	1992	18
Haddam Neck	Connecticut	582	1996	29
Big Rock Point	Michigan	72	1996	34
Maine Yankee	Maine	840	1997	25
Zion 1 and 2	Illinois	2080	1998	25
Millstone 1	Connecticut	660	1998	28
Oyster Creek	New Jersey	650	announced	29

The reasons given for nuclear plant retirement decisions generally include poor forward operating economics, and recently electric industry deregulation has been noted as an increasingly important factor. For example, Geoffrey Rothwell's assessment of the decisions to close the Yankee Rowe and Trojan plants concludes that the "plants were closed after their owners determined that the Net Present Value (NPV) of continued operations was negative or nearly negative" (Rothwell, 1997).

In the case of Maine Yankee, "economic pressure" was identified as a root cause of problems that eventually led to the unit's retirement:

> Economic pressure to be a low-cost energy producer has limited available resources to address corrective actions and some plant improvement upgrades. Management has effectively prioritized available resources, but financial pressures have caused the postponement of some needed program improvements and actions. (NRC 1996, page 71)

Maine Yankee's Cultural Assessment Team reported that

> The current economic and political environment is considered precarious, and Maine Yankee's survival is seen to be based on a formula of low cost and high production. There is an associated fear among many employees that highlighting any negative issue could endanger the plant's continued operation. . . . At Maine Yankee, the Team found an organization struggling with forces requiring unprecedented change. These include evolving performance standards as well as deregulation within the electric utility industry. (Bradford et al., 1996, pages 8-9)

Electric industry restructuring is, in general, magnifying pressure to cut costs. To the extent that cost cutting in operating budgets can be done without creating other problems this could work to the advantage of existing nuclear power plants. On the other hand, cutting current operating costs may be counter productive to the extent that cost cutting leads to declines in performance or to additional costs in the longer term. In either case, electric market deregulation is creating an environment where it is increasingly difficult to continue operating uneconomic plants. While some subsidies to nuclear plant operation have been provided for in "transition" plans, the pressure to mitigate stranded generation costs by closing uneconomic nuclear plants is considerable. At the same time, some companies may be waiting until stranded cost recovery is assured before deciding to retire uneconomic nuclear units.

2.2. Deregulation and Projections of Nuclear Generator Retirements

The recent experience with nuclear plant early retirement announcements raises the question of how this trend might or might be expected to continue into the future. Recent analyses of this question have found that a significant portion of the nuclear fleet is at risk of shutting down on the basis of poor operating economics.

For example, Geoffrey Rothwell (1998) analyzes the economics of the nuclear fleet using econometric estimates to simulate costs in a probabilistic comparison with electricity market prices. He concludes that "if costs are not reduced, there are approximately two dozen units at risk of early retirement before 2006, when nuclear power unit operating licenses begin to expire" (page 12).

Jim Riccio's analysis for Public Citizen (1998) took a more straightforward approach. Riccio compared average nuclear fuel and O&M costs for the 1994 to 1996 period with the estimated cost of replacement power in the region as estimated by the Nuclear Regulatory Commission (1992). This comparison identified 42 nuclear units that are not competitive.

Moody's Investor Services (1995) examined nuclear operating costs, and concluded that there are "at least 10 nuclear plants (out of 109 in the U.S.) that might be closed in the event of deregulation" (page 7). In November 1996 Moody's reported that

> the bond ratings of 24 nuclear operating electric utilities have been downgraded, some more than once. Only 8 IOUs [investor-owned utilities] with nuclear investments have been upgraded. . . The average bond rating for electric utilities with significant exposure to nuclear investments is Baa1 versus A2 for those with no nuclear investments and an industry-wide average of A3.

The Interstate Natural Gas Association of America released a report in May, 1998, on the "Need for Natural Gas Increases with More Nuclear Plants Shut Down." INGAA concluded that 34 of 72 US nuclear reactor sites are vulnerable to shutdown because their annual production costs are higher than projected market prices. These sites represent 34% of the nuclear generating capacity in the U.S., or 37,859 MW.

A recent annual survey of utility CEOs and managers (WIEG, 1998) found that only 42 percent of the respondents believe that "nuclear plants can compete in a price conscious market" while less than half (49 percent) believe that "most nuclear plants will remain in operation through their initial license term" – down from 67 percent in 1997. Virtually twice as many respondents (39 percent) as last year (20 percent) believe that a "large number of nuclear plants will be shut down in the next five years."

In this context of emerging competition in electricity markets and changing perceptions of the ongoing role of nuclear power generation, we set out to analyze the economics of continued plant operation.

2.3. Method and Assumptions for Nuclear Plant Retirement Analysis

The prospects for retirement of the nuclear fleet depend primarily upon the operating economics. For the most part, it is reasonable to assume that nuclear units with operating costs above the market value of their electricity will be shut down when subjected to competitive pressure.[3] Here, we've constructed a framework for simulating the unit owners' decision-making on a forward-looking basis. The basic decision-rule is that the expected present value of the costs of operating the unit must be less than the expected present value of the energy produced. Where this is not the case, the unit is assumed to be retired. Projections of present value cost and revenues are done for each unit in each year of the study.[4]

For nuclear operating costs, we calculated averages for the 6 year period from 1992 through 1997. For our Reference case, these recent period averages were simply projected into the future with no change (in real dollars) except for a modest decline in capacity factor during the last five years of a unit's license period. High and Low cases were developed as variations from the reference case, as indicated in Table 2.2.

[3] The assumption here is that sunk capital investments, whether recovered from customers or not, are largely irrelevant to the decision to continue to operate the units. The logic of this is that the sunk costs cannot be avoided. Even in the event of a bankruptcy resulting from failure to recover sunk investment, the bankruptcy court would likely require the continued operation of economical units in order to maximize revenues for creditors. Unfortunately, under conventional/tranditional regulation (and to some extent under transitional stranded cost recovery provisions) a utility may have an incentive to operate an uneconomical unit in order to provide for cost recovery from customers.

[4] As a practical matter, the analysis works backward from the last year of a unit's operating license in order to ensure that a unit with near term net annual benefits but long term net annual losses can be retired later in the unit's operating license period, in order to maximize benefits.

Table 2.2 Key Input Assumptions to Nuclear Retirement Analysis

Variable	Reference Case	Low Nuclear Generation Case (high nuclear costs and low market prices)	High Nuclear Generation Case (low nuclear costs and high market prices)
Nuclear Capacity Factor	6 year average, with annual decline at 1% in last 5 years of license	6 year average, declining at 0.25% annually, plus annual decline at 2% in last 5 years of license	6 year average, increasing at 0.25% annually, no adjustment for nearing end of license
Nuclear Fuel, O&M and Capital Additions Costs	6 year average cost per kWh, escalating at the general inflation rate	annual escalation at 0.5 percent real	annual decline at 0.5 percent real
Near-term Electricity Value (1996)[5]	1996 regional average of reported marginal energy costs plus $5/MWh for capacity value	7 percent less than the reference case	7 percent greater than the reference case
Long-term Electricity Value (2005 and beyond)	EIA's projected market prices by region (based largely upon the cost of new combined cycle generation with gas)	15 percent less than the reference case in 2020 (based upon EIA's analysis with lower natural gas prices)	13 percent greater than the reference case in 2020 (based upon EIA's analysis with higher natural gas prices)

For the value of generation from the nuclear generators, we used system marginal cost data for 1996 and projections of market prices for electricity by region produced by the EIA using its National Energy Modeling System (Beamon, 1997).[6] These assumptions, for the Reference, High, and Low cases, are summarized in Table 2.2. The EIA forecast of market prices includes 2 to 3 mills/kWh for "general and administration" costs, and so 3 mills/kWh of G&A costs were included in the nuclear costs for this analysis. G&A includes labor related benefits and taxes that are typically higher for nuclear plants than for other generating facilities.

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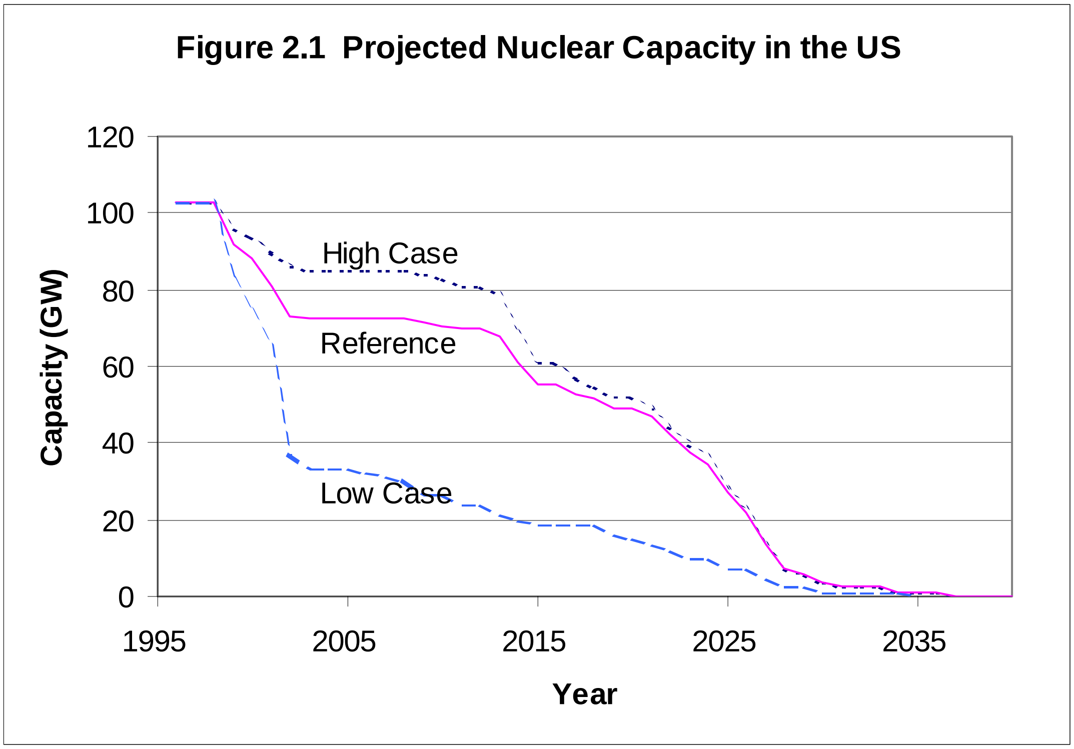
[5] Electricity market prices between 1996 and 2005 were interpolated between the "near-term" and "long-term" prices.

[6] EIA may be optimistic in its projection of the costs and performance of natural gas combined-cycle plants and in its assumption that electricity markets will be highly competitive (i.e., not subject to significant price effects of concentration of ownership and market power). We rely upon the EIA market price projections for this analysis because it is the standard government source of energy market information covering the entire country and because we can thereby show a consistent overall analysis using Department of Energy projections for the high-level waste program costs and revenues.



2.4. Results of Nuclear Plant Retirement Analysis

We find that many existing nuclear units are uneconomical to continue operating. In the reference case, 34 units are found to be uneconomical to operate. Most of these would be retired as soon as they are subjected to competitive pressure.[7] This points to an interesting economic implication of the timing of electric industry restructuring. There appear to be a number of units that are uneconomic over the full period of their remaining lives beginning in 1998, but that would be economic over shorter, later periods due to projected increases in market prices over time. If competition comes slowly or these units are protected from competitive pressures for several years, then their owner/operators may well choose to keep them open despite their uneconomic status.

In the low case, we find that most of the existing fleet of nuclear units is uneconomic to operate, and should be closed. In this case, the extent to which individual nuclear units will be retired early will be moderated by a price feedback. That is, as the first wave of

[7] We have allowed retirements on a schedule based upon EIA's summary of state electric utility deregulation activity: 1999 for states with restructuring legislation enacted, 2000 for states with a comprehensive regulatory order, 2001 for states with legislation or orders pending, 2002 for states with ongoing investigations, and 2003 for states with no significant activity (see the EIA's web site at "www.eia.doe.gov/cneaf/electricity/chg_str/tab5rev.html").

nuclear units are retired, the electricity markets will tighten and the value of capacity and energy will rise. This will make the remaining units relatively more attractive to operate.

In the high case, with very optimistic assumptions for nuclear plant costs and performance, we still find 20 nuclear units to be uneconomic to operate.

The projected operating nuclear capacity for the Reference, Low, and High cases is plotted in Figure 2.1. All three cases have total nuclear capacity in the US declining from about 100 GW today to zero by 2037, but the drop off in the early years is much steeper in the low case.

The number of nuclear of units retired early, the "lost" operating years, and the average size of the retired units are listed for our three cases in Table 2.3. In the Reference case, a total of 508 unit-years of operation are "lost" as a result of the 34 early generating unit retirements.

Limitations and caveats are identified at the conclusion of this paper, in the section on "further research." It should also be noted that the results reported here understate the extent of early retirements in that feedback from nuclear waste program fees is not incorporated in the analysis. We have conducted some initial exploration of this feedback effect – increases in the level of the high-level waste disposal fee leading to additional retirements leading to additional fee increases – and describe those results in Section 4.3 of this report.

It should also be noted here that the ranges used here for the low and high case input assumptions are rather tight. That is, experience for particular variables could easily fall outside of the range of projections incorporated here. It was decided that for this analysis, the range depicted in Figure 2.1 would serve well as a sufficiently wide range for analyzing decommissioning and spent fuel funding issues.

The particular nuclear units identified as at risk in the Reference, Low, and High cases are listed in the tables in Appendix A.

Table 2.3 Summary of Nuclear Retirements in the Reference, Low and High Cases

Case	Units Retired Prior to License Expiration Date	Total Unit Years of Operation Lost	Total Giga-Watt Years of Operation Lost	Average Size of Retired Nuclear Units (MW)
Reference Case	34	508	479	943
Low Nuclear Generation Case	90	1338	1386	1036
High Nuclear Generation Case	20	304	283	931

3. Decommissioning Funding

3.1. Background on Nuclear Plant Decommissioning

All nuclear power plants must eventually be decommissioned. The decommissioning process includes draining the plant's fluid systems; decontaminating pipes, equipment, and structural materials that have become radioactive; and, either immediately or after some delay period, dismantling the reactor and surrounding structures and shipping the radioactive waste to a low-level waste burial facility.

The "irradiated" or "spent" nuclear fuel accumulated at the site during the plant's years of operation must be removed from the spent fuel pool prior to decommissioning the facility. The cost of transporting and storing the fuel is typically not considered a part of decommissioning. In this report we will address spent nuclear fuel costs separately (in Section 4).

The Nuclear Regulatory Commission has required that commercial nuclear power plants collect funds for their eventual decommissioning, and set the funds aside in external trust funds. The primary reason for this requirement is to ensure that funds will be available for decommissioning the plants after they have retired. When a nuclear plant is retired, it no longer generates a revenue stream, and there is little incentive for its owner to spend money to clean it up. A plant owner that is under financial stress (perhaps related to the unanticipated, "premature" retirement of its nuclear asset) might not have the resources to responsibly decommission its facility. With external funding the assurance of the availability of funds for the safe and timely decommissioning of retired nuclear plants is improved.

There is also an equity argument for collecting funds for decommissioning during the operating life of a facility. That is, the customers who benefit from the electrical power produced by the nuclear plant should be responsible for paying its clean up cost. The equity considerations are complex, however. For example, for those nuclear plants that cost several billion dollars to construct it is not accurate to say that the customers bearing the brunt of those construction costs are "benefiting" as a result of receiving the excessively high priced electricity from the facility. Nonetheless, there is much merit to the concept that we should provide resources to ensure the safe dismantlement of today's nuclear plants during their operating lives, rather than leaving this responsibility to future generations.

With decommissioning funding typically based upon the license period of individual nuclear units, it is nearly certain that in the event of a shutdown prior to the end of the operating license there will be a funding shortfall. The extent of the shortfall depends upon when in its license period the unit closes, the pattern of funding, and the interest accumulated on the decommissioning fund. There have been funding shortfalls for each of the nuclear units that has been closed to-date, and this is likely to be the case for many currently operating units that are shut down in the future.

Whether and to what extent companies are allowed to recover decommissioning fund shortfalls in the event of early retirement will depend upon the institutional arrangements. Some regulatory commissions and/or legislatures may require customers to pay such charges in non-bypassable electricity distribution fees while others may require the plant owners to fund the shortfall. The principle that only costs for generators that are "used and useful" should be charged in regulated rates is long-established. On the other hand, regulators have shown a willingness to make exceptions in the case of unfunded decommissioning costs, charging such costs to customers in regulated rates even after the facility is closed.

3.2. Current Decommissioning Funding Status

In Table B.1 of Appendix B, we list the estimated decommissioning cost and the amount in the external decommissioning funds, for all of the investor-owned utilities with large amounts of nuclear entitlements. The total for the 51 IOUs listed amounts to an estimated cost of $38.8 billion (in 1997 dollars) and a fund balance of $15.1 billion. Counted in this way, the current level of the unfunded decommissioning liability amounts to $23.6 billion, or about 61 percent of the total estimated decommissioning cost in today's dollars. The decommissioning information relied upon here is based primarily upon data reported by utilities in their 10Ks, supplemented by information from regulatory proceedings in particular instances.

In Table B.2 of Appendix B the decommissioning funding information is presented by unit. For this table, some calculations were necessary. For utilities that own more than one unit, the costs were allocated based upon capacity ratings in cases where we did not have unit-specific data. For units with public power minority owners the figures were scaled up from the IOU data in order to reflect the full generating unit. Note that units owned entirely by public power entities are not included in the table since data on decommissioning funding were not available.[8]

The figures in Table B.2 include 8 nuclear units that have already been shutdown (most of which still need to be dismantled). For these units the total estimated

[8] The most significant omission is the Tennessee Valley Authority, which operates several nuclear plants and apparently does not have external trust funds for decommissioning.

decommissioning cost is $3.6 billion (in 1997 dollars) while the collected funds amount to only $1.3 billion (at year-end 1997). While state regulators have sometimes allowed utilities to recover in regulated rates the decommissioning cost shortfalls for nuclear units retired early, the magnitude of the shortfall for these 8 units (about $2.3 billion) illustrates the need for timely and adequate funding of decommissioning. In a less regulated environment, it will be increasingly difficult for utilities to recover decommissioning funding shortfalls for generators that are not operating. There are also strong equity and efficiency arguments for not requiring customers to pay for such costs in regulated rates.

Table 3.1 Nuclear Plant Decommissioning Funding Summary

	Total Estimated Decommissioning Cost (billions of 1997$)	Total Decommissioning Fund Balance (billions of 1997$)	Total Decommissioning Funding Shortfall (billions of 1997$)
Data as of Year-End 1997:			
51 Investor-Owned Utilities (listed in Table B.1)	38.8	15.1	23.6
102 IOU Nuclear Units (listed in Table B.2)	42.5	15.6	26.9
8 Closed Units	3.6	1.3	2.3
94 Operating IOU Nuclear Units	38.9	14.3	24.6
Projections:[9]			
Synapse Reference Case	38.9	31.8	7.1
Synapse Low Nuclear Case	38.9	23.6	15.3
Synapse High Nuclear Case	38.9	34.8	4.1

3.3. Estimated Decommissioning Funding Shortfalls

With annual funding amounts collected in electricity prices charged to customers, and placed in external trust funds, the current total decommissioning funding shortfall can be expected to decline over time. Still, if funding levels are based upon the operating license periods and nuclear generators are retired prior to the end of their operating licenses, the funding available for decommissioning at the time of plant closure will be inadequate.

For each of the three Synapse nuclear generation scenarios we projected the extent of the total shortfall for the nuclear industry in the US. For these estimates, it was assumed: (1) that the current decommissioning cost estimates are accurate; (2) that annual funding contributions are set in order to achieve the target levels in the year of operating license expiration;[10] and (3) that any interest on the fund balances is exactly matched by escalation in the decommissioning costs.

Given these assumptions, and the nuclear scenarios described in Section 2, we estimate that the total unfunded decommissioning liability for units retired before the end of their operating licenses would amount to $4.1 billion, $7.1 billion, and $15.3 billion, for the

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[9] Data listed for the "projections" does not include the units already closed.

[10] In practice, annual funding levels might tend to be set below the level actually required because of pressures to keep electricity prices low in the near-term. To the extent that this is the case, the resulting decommissioning funding shortfalls will tend to be even higher than those estimated here.

high, reference, and low scenarios, respectively. These figures are in 1997 dollars, and do not include the units operated by public power entities or the units already closed.

The current set of decommissioning cost estimates is, of course, subject to considerable uncertainty. The rapid rate of escalation in the estimates over the past two decades[11] suggests that further escalation is a distinct possibility, and that the unfunded liability could be much greater than the figures reported here.

[11] Nuclear decommissioning cost estimates escalated at an average annual rate of about 10 percent real since 1977 (Biewald 1997).

4. Spent Nuclear Fuel Transportation and Long-Term Storage Costs

4.1. High Level Radioactive Waste Policy in the U.S.

The prospect of nuclear plant retirements has implications for spent fuel disposal as well. Our nation's policy for spent nuclear fuel disposal is based upon two potentially conflicting ideas. First, the costs of disposal are to be fully paid for by the owners and generators of spent nuclear fuel through a fee paid to the DOE for nuclear kWh generated and sold. At the same time, the DOE is precluded from changing the fee retroactively. That is, the DOE can raise the fee that it charges per kWh of future generation from nuclear power plants, but it cannot go back to nuclear electricity generated in prior years if the program revenues are found to be inadequate to cover program costs. This policy results in a classic dilemma when confronted with numerous nuclear plant retirements.

The DOE periodically checks whether the one mill per kWh fee (along with some one-time payments) will be adequate to cover the costs of the disposal program.[12] In estimating the revenue side of its program, the DOE typically assumes that all existing nuclear plants will operate (and pay the DOE one mill per kWh) to the end of their operating licenses, unless they have specifically announced plans to close early. DOE's last assessment of the fee adequacy (done in October, 1996) found the one mill fee to be adequate. The DOE is expected to produce a new fee adequacy study soon.

[12] The Nuclear Waste Policy Act requires annual reviews of fee adequacy, but in practice, the DOE has produced seven such studies, in 1983, 1984, 1985, 1986, 1987, 1990, and 1996.

Table 4.1 Funding Scenarios for High Level Nuclear Waste Disposal Program

Scenario	Revenues	Costs of Waste Disposal Program	Shortfall in 2071 (billions of 1997 $)	Necessary Fee to Cover Costs
1. DOE 1996 Fee Adequacy Assessment With Real Interest at 2%	Nuclear generation from EIA 1994 projection, adjusted to remove cancelled TVA units.	DOE's cost estimate of from September 1995 TSLCC Report.[13]	$1.9 billion	1.1 mills/kWh
2. DOE with Synapse Reference Nuclear Projection	Early retirement of 34 additional nuclear units (decreasing DOE's generation forecast by about 10%)	DOE projected program costs decreased by 2.8% recognizing 5.6% lower total nuclear generation with half of costs fixed.	$3.8 billion	1.2 mills/kWh
3. DOE with Synapse Low Nuclear Projection	Early retirement of 90 additional nuclear units (decreasing DOE's generation forecast by about 57%)	DOE projected program costs decreased by 16.4% recognizing 32.8% lower total nuclear generation with half of costs fixed.	$6.7 billion	1.5 mills/kWh
4. Independent Cost Assessment	Nuclear generation from EIA 1994 projection, adjusted to remove cancelled TVA units.	Cost estimate from PIC's Independent Cost Assessment.[14]	$45.9 billion	2.6 mills/kWh
5. Independent Cost Assessment with Synapse Reference Nuclear Projection	Early retirement of 34 additional nuclear units (decreasing DOE's generation forecast by about 10%)	Independently projected program costs decreased by 2.8% recognizing 5.6% lower total nuclear generation with half of costs fixed.	$46.5 billion	2.9 mills/kWh
6. Independent Cost Assessment with Synapse Low Nuclear Projection	Early retirement of 90 additional nuclear units (decreasing DOE's generation forecast by about 57%)	Independently projected program costs decreased by 16.4% recognizing 32.8% lower total nuclear generation with half of costs fixed.	$43.0 billion	4.5 mills/kWh

4.2. Nuclear Waste Funding Scenarios and Shortfalls

[13] The estimate is $28 billion on a forward basis in 1996 dollars for the civilian portion of the program. Source: DOE/RW-0490, "Nuclear Waste Fund Fee Adequacy: An Assessment, October, 1996.

[14] The estimate is $43 billion on a forward basis in 1996 dollars for the civilian portion of the program. Source (Planning Information Corporation, 1998).

In Table 4.1, we summarize six scenarios for the spent fuel disposal program cash flow. In the first case, we take the analysis of the DOE's latest fee adequacy report with one modification: the assumed real interest rate is reduced to 2.0 percent. DOE's report presents results for a range of interest rate assumptions, but appears to favor a 2.8 percent rate based on a DRI forecast. We believe that 2.8 percent is optimistic for a risk-free return, and that a figure of 2.0 is preferable for waste fund planning purposes. Ibbotson (1998) for example reports a long-term inflation adjusted rate for government bonds of 2.1 percent.[15]

This first scenario shows a resulting fund shortfall of $1.9 billion (in 1997$) in the year 2071, which can be avoided by increasing the fee slightly – to 1.1 mills per kWh.[16] This case essentially forms the basis for the DOE's belief that the funding level need not be increased.

In the second scenario for the nuclear waste program, we incorporate the Synapse reference case for nuclear unit retirements. This results in a forecast of future nuclear generation (and hence revenue from the fee) that is about 10 percent lower than that assumed by the DOE. Because nearly half of the total nuclear generation from our country's fleet of nuclear units is behind us, however, the total nuclear generation (and hence the approximate total amount of nuclear waste) is reduced by only 5.6 percent. For the cost side of the program, we assume here that the disposal program costs are half fixed (unchanging with the amount of waste generated) and half variable (scaling proportionally with the amount of waste generated). The specific nature of how the program costs change with differing quantities of waste generated, transported, and stored, over different time periods is an important topic for detailed engineering analysis which remains to be undertaken. Note, however, that the decrease in program costs is likely to be much lower than the decrease in revenues, as a result of the structure of the program funding mechanism and the fact that we are at or near the mid-point in cumulative electricity production from our nation's nuclear plants. The result for the reference case scenario is a projected funding shortfall of $3.8 billion (in 1997$) in the year 2071, at the conclusion of the spent fuel program. A relatively minor adjustment to the one mill per kWh fee – to 1.2 mills per kWh – is enough to offset the shortfall, if the adjustment is made in the next few years.

A third scenario, with Synapse's Low case projection of nuclear generation, shows a funding shortfall of $6.7 billion (in 1997$ in the year 2071). This can be avoided by a

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[15] This is the geometric mean for the period from 1926 to 1997 for both long-term and intermediate term government bonds (page 123).

[16] Note that while most of the cost figures in this analysis are reported in constant dollars, where we report fee levels for the nuclear waste program these are typically stated in nominal dollars, consistent with the treatment of the fees by the DOE. That is, the DOE does not have the fee level indexed to inflation.

fee increase to 1.5 mills per kWh. Here, the adjustment to the program costs amounts to 16.4 percent, based upon the same half fixed, half variable assumption used in the prior case.

There are many reasons to believe that the current official estimates of program costs are understated. A recent Independent Cost Assessment prepared for the Nevada Agency for Nuclear Projects (PIC, 1998) found that program costs are likely to be roughly 50 percent higher than assumed by the DOE. In our fourth nuclear waste program scenario, we substitute this cost estimate for the DOE's, and find an expected shortfall of $45.9 billion (in 1997$ in 2071). This huge funding shortfall, a gross violation of the principle that the costs of the program are to be recovered from the generators of the waste in the fee charged to nuclear generation, can be avoided by increasing the fee to 2.6 mills per kWh.

In scenarios 5 and 6, we combine the Synapse nuclear plant retirement projections with the independent cost estimates for the spent fuel program. The results are funding shortfalls similar to that of scenario 4, but the necessary fee increases are larger, owing to the decreases in nuclear generation. In cases 5 and 6, the fee must be raised to 2.9 and 4.5 mills per kWh, respectively.

4.3. Feedback Effect of Fee Increases Upon Nuclear Retirements

As the spent fuel disposal fee is increased to internalize the costs of nuclear waste, there is an important and troubling feedback effect upon fee adequacy. A higher fee will tend to cause additional nuclear unit retirements, which in turn will lead to a need to increase the fee. It is quite possible that in some scenarios this reinforcing feedback could result in a situation where increasing the fee is counterproductive. This prospect should be avoided, by making necessary adjustments to the fee in a timely manner, as the need becomes apparent. Delays in implementing fee increases could make it impossible to satisfy the "full cost recovery" principle for program funding, without implementing retroactive assessments.

As an initial investigation of this feedback effect, we analyzed some variations on Scenario 4. In Scenario 4 we have the Synapse Reference case projection of nuclear generation and PIC's independent cost estimate for the waste disposal program. As reported in Table 4.1, in order for the fee revenues to cover the cost of the program in this scenario, the one mill per kWh fee would need to be raised to 2.9 mills starting in 1999. When we put this increased fee level into our model for projecting nuclear retirements, we find that an additional 10 nuclear units should be retired early. The total early retirements in this scenario amount to 44 units, 671 unit-years of operation, or 654 giga-watt years.[17] This, of course, in turn has implications for the level of the fee. With less nuclear generation the fee would have to be raised further in order to cover the full cost of the waste disposal program, possibly resulting in additional nuclear retirements.

It is interesting also to consider the implications of delaying the fee increase. As the timing of the increases is deferred, the magnitude of the required fee goes up since there is less prospective nuclear generation to apply the fee to. We estimate that if the fee increase were delayed for five years, then instead of increasing to 2.9 mills per kWh, the fee would need to be increased to 4.0 mills (starting in January of 2004). If the fee increase is delayed by ten years, to 2009, then the level of the required fee is 6.0 mills per kWh.[18]

[17] These figures can be viewed relative to the reference case results, which had early retirement of 34 units, 508 unit-years of operation, and 479 giga-watt years.

[18] These fee levels are stated in nominal dollars, consistent with the treatment of the one mill fee.

5. Conclusion

5.1. Limitations of the Analysis and Areas for Further Research

The analysis described here depends upon numerous simplifying assumptions. Future research should address key issues including refinement of the nuclear cost and performance projections, the incorporation of feedbacks into the methodology, and the exploration of policy options for internalizing costs and eliminating subsidies to both fossil and nuclear generation.

The development of nuclear generation projections depends critically upon trends in nuclear plant operating costs and performance with age, particularly during the final years of a unit's operating license. The analysis presented above considers a fairly wide range for these parameters, and not surprisingly comes to a wide range for the resulting high and low scenarios. Some uncertainty is inevitable, but further research could help to indicate likely trends, perhaps narrowing the range of input assumptions. Also, the experience toward the end of a unit's license period deserves additional attention. It may be increasingly difficult to maintain a staff of skilled and motivated employees at a nuclear facility that is scheduled to be closed and in the context of an industry that is in decline.

The range and volatility of electricity prices in regional markets is a worthy topic for analysis. In the study described above we considered a range of projected market prices, but we did not examine the role of price volatility. On the one hand, nuclear power offers an advantage relative to fossil fuels by diversifying exposure to oil and gas price volatility. On the other hand, nuclear power has experienced its own operating cost escalation in the past. Moreover, a period of several years with market prices below the longer term average could lead to a near term increase in nuclear unit retirements.

Plant and company specific considerations, including plans for major equipment replacement, should also be addressed in future research projects. For facilities facing major equipment investments such as steam generator replacement, the economics of continued operation might be unfavorable, particularly in a deregulated market. In this analysis we have taken a broad view of the nuclear industry using data for cost and performance in the recent past. The result is that we present view of things that is smooth in the sense that we do not recognize the implications of large specific repairs required in particular future years. Also, the results presented here, while broadly reasonable for the industry as a whole, are not intended to be accurate for individual units.

The role of potential nuclear plant license extensions should be examined. Some units may be granted approval to operate for an additional period beyond the expiration of their current operating licenses. If license extension becomes common, then funding shortfalls projected here could be substantially decreased.

Tightening environmental regulations for fossil-fueled power generation should be considered. Additional costs could be imposed upon fossil fuel generators to reduce emissions of sulfur dioxide, nitrogen oxides, particulates, mercury (and other toxics), and carbon dioxide. Such additional regulations would tend to improve the economics of nuclear power plant operation. In most regions, however, in the longer term the marginal resource type determining the market price for wholesale electricity is expected to be natural gas fired combined-cycle generation. Since these gas units are relatively quite clean, the impact of tighter emissions standards will be felt mainly by existing, inframarginal fossil fuel generators.

Feedback of nuclear retirements upon market prices for electricity could be an important phenomenon, particularly in regions and scenarios where several units are retired early. The closure of baseload generators would tend to increase market prices, making additional early retirements less economically attractive. This is a complex phenomenon that can be readily modeled with a computerized system dispatch simulation model. Such modeling would tend to be for particular regions, and is beyond the scope of the analysis conducted here.

For nuclear plant decommissioning cost estimates and fund balances, the data presented here has good coverage of investor-owned utilities. Additional research could usefully be aimed at determining the status of decommissioning funding for public owners of nuclear power plants.

The nuclear waste fee results are sensitive to the relationship between total nuclear waste volume and DOE spent fuel program costs. Here we made a simple scaling assumption: that one half of the costs of the high level waste program are fixed (do not vary with the amount of waste) and half are variable (scaling proportionately with the amount of waste). This is a relationship that could be usefully explored by detailed engineering analysis of the nuclear waste program cost components.

Proposals for interim storage of nuclear waste and litigation about responsibility for costs incurred as a result of delays in the DOE development of high-level waste storage facility both play an important role in our overall nuclear waste policy. These considerations, however, are beyond the scope of the present analysis.

Financial assumptions (i.e., the inflation rate and real interest rate) have a great influence upon the economics of the spent fuel disposal program. While we are comfortable with the assumptions employed in this analysis, further research into the appropriate financial assumptions to use in this analysis would certainly be useful. The cost streams for the high level waste program extend well into the next century, and the economics are quite sensitive to the financial assumptions.

Consideration should be given to the role of Price-Anderson liability limits and nuclear insurance in a competitive electricity market. If the market is to function efficiently, then subsidies such as the limit on liability in the event of a nuclear accident should be eliminated. It may be possible for the market to internalize these costs in the form of insurance premiums.

There is also a crucial feedback between nuclear waste disposal fees and the number of units that are uneconomic to operate. As the fees are increased (due, in part, to early nuclear plant retirements) the economics deteriorate for continued operation of the remaining plants, perhaps leading to additional early retirements. Our initial research suggests that this feedback loop could be strong enough in some scenarios to lead to the early shutdown of a substantial amount of nuclear generating capacity. In a situation where increasing disposal fees cause additional early retirements there would be tremendous political pressure to break the loop by violating one of the policy principles of the nuclear waste disposal program – either charging fees retroactively upon prior nuclear generation or obtaining funds from general tax revenues.

5.2. Conclusions and Policy Implications

Perhaps, the most important set of considerations for immediate attention are those that are within the control of regulators and policy-makers. As the electric utility industry is deregulated, we will have to decide whether and to what extent specific generating technologies should be subsidized. As a general principle of competition, the owners of nuclear power plants should be required to bear their full costs, including accident risk, nuclear waste disposal, and the costs of dismantling the plants. The public policy implications are far-reaching, particularly through time.

It appears, for example, that the one mill per kWh fee for spent fuel transportation and long-term storage may be inadequate to fund the program. At the same time, legislation has been proposed that would cap the fee at one mill. This could lead to a violation of the principle of "full cost recovery" of the Nuclear Waste Policy Act, "under which all costs related to the waste disposal services will be paid for by the owners and generators of SNF and civilian and defense high-level radioactive waste."[19] If we wait to increase the fee, then we may find that at some future time an even higher increase is unavoidably necessary to cover the costs of the program but that the higher fee will lead to additional plant retirement decisions, undermining the economics of the program further. Indeed, it is likely that we are already beginning to face such a situation.

[19] This language is quoted from the DOE's 1996 Nuclear Waste Fund Fee Adequacy study, page 5.

Similarly, the current understanding of projected nuclear decommissioning costs poses a policy dilemma in a deregulated electricity market. Recovery of "catch-up" amounts through wires charges and other "stranded cost" charges imposes a special burden on electric customers in geographic areas historically served by nuclear power plants, potentially distorting market signals and dampening economic activity in those areas. While equity considerations may justify such charges for past consumption of nuclear energy, both fairness and efficiency militate against such subsidies for future consumption of nuclear power.

Consequently, the advent of competition and deregulation will inevitably force policy-makers and regulators to face the "bottom-line" question that has troubled nuclear power from the earliest stages of its commercial development: who pays how much and for how long? The answer to this question will no doubt be controversial, but is nonetheless essential and unavoidable. While this paper does not provide the answer, we hope that it offers some useful insights into the nature and the magnitude of the problem.

6. References

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Appendix A: Nuclear Units at Risk

Table A.1 Nuclear Units Identified at Risk in the Reference Case

Nuclear Units Retired Early	NERC Region	License Expiration Year	Retirement Year	Years Early
Beaver Valley – 1	ECAR	2016	1999	17
Beaver Valley – 2	ECAR	2027	1999	28
Brunswick – 1	SERC	2016	2002	14
Brunswick – 2	SERC	2014	2002	12
Clinton – 1	MAIN	2026	1999	27
Cooper – 1	MAPP	2014	2002	12
Crystal River – 3	SERC	2016	2003	13
Davis-Besse – 1	ECAR	2017	2001	16
Donald C Cook – 1	ECAR	2014	2001	13
Donald C Cook – 2	ECAR	2017	2001	16
Dresden - 2	MAIN	2006	1999	7
Dresden - 3	MAIN	2011	1999	12
Duane Arnold - 1	MAPP	2014	2002	12
Fermi - 2	ECAR	2025	2001	24
Fort Calhoun - 1	MAPP	2013	2002	11
Ginna - 1	NPCC	2009	2000	9
H B Robinson - 2	SERC	2010	2001	9
Indian Point 3 - 3	NPCC	2015	2000	15
Millstone - 2	NPCC	2015	1999	16
Monticello - 1	MAPP	2010	2002	8
Palisades - 1	ECAR	2007	2001	6
Peach Bottom - 2	MAAC	2013	1999	14
Perry - 1	ECAR	2026	2001	25
Pilgrim - 1	NPCC	2012	1999	13
Prairie Island - 1	MAPP	2013	2002	11
Prairie Island - 2	MAPP	2014	2002	12
Quad Cities - 1	MAIN	2012	1999	13
Quad Cities - 2	MAIN	2012	1999	13
Riverbend - 1	SPP	2025	2002	23
Salem - 1	MAAC	2016	2000	16
Salem - 2	MAAC	2020	2000	20
San Onofre - 3	WSCC	2013	1999	14
Three Mile Island - 1	MAAC	2014	1999	15
Wnp - 2	WSCC	2024	2002	22

Table A.2 Nuclear Units Identified at Risk in the High Nuclear Generation Case

Nuclear Units Retired Early	NERC Region	License Expiration Year	Retirement Year	Years Early
Beaver Valley - 1	ECAR	2016	1999	17
Beaver Valley - 2	ECAR	2027	1999	28
Brunswick - 2	SERC	2014	2002	12
Cooper - 1	MAPP	2014	2002	12
Crystal River - 3	SERC	2016	2003	13
Davis-Besse - 1	ECAR	2017	2001	16
Dresden - 2	MAIN	2006	1999	7
Dresden - 3	MAIN	2011	1999	12
Duane Arnold - 1	MAPP	2014	2002	12
Fermi - 2	ECAR	2025	2001	24
Fort Calhoun - 1	MAPP	2013	2002	11
Indian Point 3 - 3	NPCC	2015	2000	15
Millstone - 2	NPCC	2015	1999	16
Palisades - 1	ECAR	2007	2001	6
Perry - 1	ECAR	2026	2001	25
Pilgrim - 1	NPCC	2012	1999	13
Quad Cities - 1	MAIN	2012	1999	13
Quad Cities - 2	MAIN	2012	1999	13
Riverbend - 1	SPP	2025	2002	23
Salem - 1	MAAC	2016	2000	16

Table A.3 Nuclear Units Identified at Risk in the Low Nuclear Generation Case

Nuclear Units Retired Early	NERC Region	License Expiration Year	Retirement Year	Years Early
Arkansas Nuclear One - 1	SPP	2014	2002	12
Arkansas Nuclear One - 2	SPP	2018	2002	16
Beaver Valley - 1	ECAR	2016	1999	17
Beaver Valley - 2	ECAR	2027	1999	28
Browns Ferry - 3	SERC	2016	2009	7
Brunswick - 1	SERC	2016	2002	14
Brunswick - 2	SERC	2014	2002	12
Calvert Cliffs - 1	MAAC	2014	2000	14
Calvert Cliffs - 2	MAAC	2016	2000	16
Catawba - 1	SERC	2024	2014	10
Catawba - 2	SERC	2026	2019	7
Clinton - 1	MAIN	2026	1999	27
Comanche Peak - 1	ERCOT	2030	2002	28
Comanche Peak - 2	ERCOT	2033	2002	31
Cooper - 1	MAPP	2014	2002	12
Crystal River - 3	SERC	2016	2003	13
Davis-Besse - 1	ECAR	2017	2001	16
Diablo Canyon - 1	WSCC	2021	1999	22
Diablo Canyon - 2	WSCC	2025	2011	14
Donald C Cook - 1	ECAR	2014	2001	13
Donald C Cook - 2	ECAR	2017	2001	16
Dresden - 2	MAIN	2006	1999	7
Dresden - 3	MAIN	2011	1999	12
Duane Arnold - 1	MAPP	2014	2002	12
Edwin I Hatch - 1	SERC	2014	2002	12
Edwin I Hatch - 2	SERC	2018	2002	16
Fermi - 2	ECAR	2025	2001	24
Fort Calhoun - 1	MAPP	2013	2002	11
Ginna - 1	NPCC	2009	2000	9
Grand Gulf - 1	SERC	2022	2002	20
H B Robinson - 2	SERC	2010	2001	9
Harris - 1	SERC	2026	2002	24
Hope Creek - 1	MAAC	2026	2000	26
Indian Point - 2	NPCC	2013	2008	5
Indian Point 3 - 3	NPCC	2015	2000	15
James A Fitzpatrick - 1	NPCC	2014	2000	14
Joseph M Farley - 1	SERC	2017	2002	15
Joseph M Farley - 2	SERC	2021	2002	19
Kewaunee - 1	MAIN	2013	2002	11
La Salle - 1	MAIN	2022	1999	23
La Salle - 2	MAIN	2023	1999	24
McGuire - 1	SERC	2021	2002	19
McGuire - 2	SERC	2023	2002	21

Millstone - 2	NPCC	2015	1999	16
Millstone - 3	NPCC	2025	1999	26
Monticello - 1	MAPP	2010	2002	8
Nine Mile Point - 1	NPCC	2009	2000	9
Nine Mile Point - 2	NPCC	2026	2021	5
North Anna - 1	SERC	2018	2009	9
North Anna - 2	SERC	2020	2013	7
Oconee - 1	SERC	2013	2007	6
Oconee - 2	SERC	2013	2011	2
Oconee - 3	SERC	2014	2001	13
Palisades - 1	ECAR	2007	2001	6
Palo Verde - 1	WSCC	2024	2020	4
Palo Verde - 2	WSCC	2025	2022	3
Palo Verde - 3	WSCC	2027	2023	4
Peach Bottom - 2	MAAC	2013	1999	14
Peach Bottom - 3	MAAC	2008	1999	9
Perry - 1	ECAR	2026	2001	25
Pilgrim - 1	NPCC	2012	1999	13
Prairie Island - 1	MAPP	2013	2002	11
Prairie Island - 2	MAPP	2014	2002	12
Quad Cities - 1	MAIN	2012	1999	13
Quad Cities - 2	MAIN	2012	1999	13
Riverbend - 1	SPP	2025	2002	23
Salem - 1	MAAC	2016	2000	16
Salem - 2	MAAC	2020	2000	20
San Onofre - 2	WSCC	2013	1999	14
San Onofre - 3	WSCC	2013	1999	14
Seabrook - 1	NPCC	2026	1999	27
Sequoyah - 1	SERC	2020	2002	18
Sequoyah - 2	SERC	2021	2002	19
South Texas - 1	ERCOT	2027	2002	25
South Texas - 2	ERCOT	2028	2002	26
St. Lucie - 1	SERC	2016	2003	13
St. Lucie - 2	SERC	2023	2003	20
Summer - 1	SERC	2022	2001	21
Surry - 1	SERC	2012	1999	13
Surry - 2	SERC	2013	2006	7
Susquehanna - 2	MAAC	2024	2013	11
Three Mile Island - 1	MAAC	2014	1999	15
Turkey Point - 3	SERC	2012	2003	9
Turkey Point - 4	SERC	2013	2003	10
Vogtle - 1	SERC	2027	2019	8
Vogtle - 2	SERC	2029	2009	20
Waterford - 3	SPP	2024	2002	22
Watts Bar - 1	SERC	2036	2035	1
Wnp - 2	WSCC	2024	2002	22
Wolf Creek - 1	SPP	2025	2002	23

Appendix B: Nuclear Plant Decommissioning Funding for Investor Owned Utilities

Table B.1 Decommissioning Funding Status by Company

Company Name	Decommissioning Cost Estimates (Millions of 1997$)	Decommissioning Fund Balance at Year End 1997 (Millions of $)	Unfunded Portion (Millions of 1997 $)	Percent of Estimated Costs Currently Funded (%)
AEP	1,152	381	771	33%
Atlantic	165	82	83	50%
Baltimore G&E	571	145	426	25%
BECo	462	152	311	33%
Carolina P&L	1,094	246	849	22%
Centerior	656	182	474	28%
Central and South West	269	46	224	17%
Central Hudson G&E	78	11	67	14%
CMS Energy	903	486	417	54%
Commonwealth Edison	4,656	1,856	2,800	40%
Consolidated Edison	720	212	508	29%
Delmarva	216	47	170	22%
Detroit Edison	545	239	306	44%
Dominion Resources	1,120	569	551	51%
DQE	315	47	268	15%
Duke Power	1,391	422	969	30%
El Paso Electric	239	38	201	16%
Entergy	2,042	589	1,453	29%
Florida Progress Corp.	454	267	187	59%
FPL Group	1,500	998	502	67%
GPU	1,265	580	685	46%
Houston Industries	281	93	188	33%
IES Industries	277	78	199	28%
Illinois Power	549	63	486	11%
Kansas City Power	417	40	377	10%
Long Island Lighting Co	151	20	131	13%
Madison G&E	79	59	20	75%
MidAmerica	477	172	306	36%
Niagara Mohawk	939	216	723	23%
Northeast Utilities	1,482	503	979	34%
NU share of Yankees	606	250	356	41%
Northern States MN	981	400	581	41%
NY State G&E	112	13	99	12%
Ohio Edison	467	110	357	24%
PECO	1,500	320	1,180	21%

PG&E	1,429	1,071	358	75%
Pinnacle West	460	125	335	27%
PP&L	793	163	630	21%
PS Enterprise Group	1,029	458	571	45%
PS New Mexico	163	31	132	19%
Rochester G&E	427	133	294	31%
San Diego G&E	401	399	2	100%
SoCal Edison	2,100	1,400	700	67%
South Carolina E&G	271	73	198	73%
Southern Company	1,473	387	1,086	26%
Texas Utilities	675	160	515	24%
Union Electric	451	122	329	27%
Western Resources	196	44	152	22%
Wisconsin Energy	404	404	0	100%
Wisconsin PS	182	134	48	74%
WPL	181	112	69	62%
Total	**38,765**	**15,143**	**23,622**	**39%**

Table B.2 Decommissioning Funding Status By Generating Unit

	Total (100%) Decom. Est. millions 1997 $	Total Trust Fund Balance (millions $)	License Expiration Year	Sources
Arkansas Nuclear One - 1	422	123	2014	Entergy 1998 10K
Arkansas Nuclear One - 2	441	128	2020	Entergy 1998 10K
Beaver Valley - 1	344	85	2016	DQE 1998 10K, FirstEnergy 1998 10K
Beaver Valley - 2	341	81	2027	DQE 1998 10K, FirstEnergy 1998 10K
Big Rock Point - 1	330	41	*	CMS Energy 1998 10K
Braidwood - 1	233	82	2028	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Braidwood - 2	355	80	2028	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Brunswick - 1	316	119	2017	Carolina Power & Light 1998 10K
Brunswick - 2	297	119	2015	Carolina Power & Light 1998 10K
Byron - 1	230	93	2025	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Byron - 2	329	82	2027	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Callaway - 1	451	122	2024	Union Electric 1998 10K
Calvert Cliffs - 1	287	73	2015	Baltimore Gas & Electric 1998 10K
Calvert Cliffs - 2	284	72	2017	Baltimore Gas & Electric 1998 10K
Catawba - 1	310	211	2025	Duke 1997 10K
Catawba - 2	310	211	2026	Duke 1997 10K
Clinton - 1	549	63	2027	Illinois Power 1998 10K
Comanche Peak - 1	271	60	2030	Texas Utilities 1998 10K
Comanche Peak - 2	404	60	2033	Texas Utilities 1998 10K
Cooper - 1	494	156	2014	MidAmerica 1998 10K
Crystal River - 3	454	267	2017	Florida Power 1998 10K
Davis-Besse - 1	332	85	2017	FirstEnergy 1998 10K
Diablo Canyon - 1	511	410	2025	CPUC App. No. 97-12-020, Exh. No. PG&E-6, pages 14c-12, 14c-13; ORA Electric Department Results of Operations Report for Pacific Gas and Electric Company, June 1998, page 12-8.
Diablo Canyon - 2	724	524	2026	CPUC App. No. 97-12-020, Exh. No. PG&E-6, pages 14c-12, 14c-13; ORA Electric Department Results of Operations Report for Pacific Gas and Electric Company, June 1998,

				page 12-8.
Donald C Cook - 1	581	192	2015	AEP 1998 10K
Donald C Cook - 2	571	189	2018	AEP 1998 10K
Dresden - 2	359	160	2010	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Dresden - 3	529	151	2011	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Duane Arnold - 1	396	142	2014	IES Industries 1998 10K
Edwin I Hatch - 1	402	161	2015	Southern Company 1998 10K
Edwin I Hatch - 2	407	163	2019	Southern Company 1998 10K
Fermi - 2	523	203	2028	Detroit Edison 1998 10K
Ginna - 1	309	84	2010	Rochester Gas & Electric 1998 10K
Grand Gulf - 1	445	95	2025	Entergy 1998 10K
H B Robinson - 2	282	87	2011	Carolina Power & Light 1998 10K
Harris - 1	372	107	2027	Carolina Power & Light 1998 10K
Hope Creek - 1	467	210	2027	Atlantic Energy 1998 10K, PSE&G 1998 10K
Indian Point - 2	154	45	2013	Consolidated Edison 1998 10K
Indian Point 3	566	167	2016	Consolidated Edison 1998 10K
Joseph M Farley - 1	289	119	2017	Southern Company 1998 10K
Joseph M Farley - 2	289	119	2021	Southern Company 1998 10K
Kewaunee - 1	442	333	2014	Madison Gas & Electric 1998 10K
La Salle - 1	368	126	2024	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
La Salle - 2	430	122	2026	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Limerick - 1	509	167	2026	PECO 1998 10K
Limerick - 2	509	167	2030	PECO 1998 10K
Maine Yankee - 1	867	200	*	Northeast Utilities 1998 10K
McGuire - 1	314	95	2021	Duke 1997 10K
McGuire - 2	314	95	2024	Duke 1997 10K
Millstone - 1	483	221	*	Northeast Utilities 1998 10K
Millstone - 2	432	149	2015	Northeast Utilities 1998 10K
Millstone - 3	553	151	2026	Northeast Utilities 1998 10K
Monticello - 1	318	130	2011	Northern States 1998 10K
Nine Mile Point - 1	656	165	2009	Niagara Mohawk 1998 10K
Nine Mile Point - 2	691	83	2028	Niagara Mohawk 1998 10K, Rochester G&E 1998 10K
North Anna - 1	279	152	2018	Dominion Resources 1998 10K
North Anna - 2	287	143	2020	Dominion Resources 1998 10K
Oconee - 1	228	69	2013	Duke 1997 10K
Oconee - 2	228	69	2014	Duke 1997 10K
Oconee - 3	230	70	2014	Duke 1997 10K
Oyster Creek - 1	423	150	*	GPU 1998 10K
Palisades - 1	573	445	2012	CMS Energy 1998 10K
Palo Verde – 1	527	143	2026	Pinnacle West 1998 10K

Palo Verde – 2	527	143	2026	Pinnacle West 1998 10K
Palo Verde - 3	527	143	2028	Pinnacle West 1998 10K
Peach Bottom - 2	502	165	2014	PECO 1998 10K, Atlantic Energy 1998 10K, Delmarva 1998 10K, and PSE&G 1998 10K
Peach Bottom - 3	17	6	2014	PECO 1998 10K, Atlantic Energy 1998 10K, Delmarva 1998 10K, and PSE&G 1998 10K
Perry - 1	449	115	2027	DQE 1998 10K, FirstEnergy 1998 10K
Pilgrim - 1	462	152	2012	Boston Edison 1998 10K
Point Beach - 1	202	202	2010	Wisconsin Electric 1998 10K
Point Beach - 2	202	202	2012	Wisconsin Electric 1998 10K
Prairie Island - 1	332	200	2014	Northern States 1998 10K
Prairie Island - 2	332	200	2014	Northern States 1998 10K
Quad Cities - 1	329	111	2012	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Quad Cities - 2	508	111	2012	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Riverbend - 1	428	187	2026	Entergy 1998 10K
Salem - 1	509	167	2017	PECO 1998 10K, Atlantic Energy 1998 10K, Delmarva 1998 10K, and PSE&G 1998 10K
Salem - 2	509	167	2021	PECO 1998 10K, Atlantic Energy 1998 10K, Delmarva 1998 10K, and PSE&G 1998 10K
San Onofre - 1	386	184	*	Southern California Edison 1998 10K
San Onofre - 2	953	456	2023	Southern California Edison 1998 10K
San Onofre - 3	953	456	2024	Southern California Edison 1998 10K
Seabrook - 1	469	74	2030	Northeast Utilities 1998 10K
South Texas - 1 & 2	1105	302	2028	Houston Industries 1998 10K, Central and South West 1998 10K
St. Lucie - 1	378	263	2016	FPL 1998 10K
St. Lucie - 2	378	224	2023	FPL 1998 10K
Summer - 1	271	73	2024	South Carolina Electric & Gas 1998 10K
Surry - 1	272	157	2012	Dominion Resources 1998 10K
Surry - 2	274	152	2013	Dominion Resources 1998 10K
Susquehanna - 1	384	79	2023	Pennsylvania PUC Docket No. R-00973954, Response to Interrogatories of the Environmentalists, Set 3, Questions 127and 139.
Susquehanna - 2	497	66	2025	Pennsylvania PUC Docket No. R-00973954, Response to Interrogatories of the Environmentalists, Set 3, Questions 127and 139.
Three Mile Island - 1	409	204	2014	GPU 1998 10K
Three Mile Island - 2	433	225	*	GPU 1998 10K
Turkey Point - 3	338	236	2012	FPL 1998 10K
Turkey Point - 4	338	236	2013	FPL 1998 10K
Vermont Yankee - 1	505	193	2012	Northeast Utilities 1998 10K

Vogtle - 1	395	83	2027	Southern Company 1998 10K
Vogtle - 2	395	83	2029	Southern Company 1998 10K
Waterford - 3	351	65	2025	Entergy 1998 10K
Wolf Creek - 1	870	85	2025	Kansas City Power & Light 198 10K
Zion - 1	237	125	*	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Zion - 2	440	125	*	Illinois Commerce Commission No.97-0110 Attachment C 1997 Rider 13
Total	**42485**	**15601**		

*Units with an asterisk in the column for license expiration year are either closed or closing imminently. See Section 2, Table 2.1.

Appendix C: High Level Waste Program Funding Calculations

Table C.1
Nuclear Waste Program Funding Scenario 1
DOE 1996 Fee Adequacy Assessment With Real Interest at 2%

Real Interest Rate		2.000%								
Inflation		3.800%								
T&D		6.000%								
1994 EOY Fund		5291	(millions of 1994 $)							
Fee Through 1998		1.000	(nominal mills/kWh)							
Fee In 1999 and +		**1.067**	(nominal mills/kWh)							
					DOE Fee Adequacy Summary of Nuclear Waste Fund Cash Flows (In millions of 1997 Dollars)					
	One-Time Fee Payments (millions 1994$)	**Civilian Share of TSLCC (millions 1994$)**	**Nuclear Gener-ation (1000 GWH)**	**Fee (1997 mills/ kWh)**		**Mil Fee Payments**	**One-Time Fee Payments**	**Income From Investing**	**Civilian Share of TSLCC**	**EOY Fund Balance**
to 1994		3745			to 1994				4188	5917
1995	0	440	653	1.077	1995	661	0	118	492	6205
1996	0	472	653	1.038	1996	637	0	124	528	6438
1997	0	506	652	1.000	1997	613	0	129	566	6614
1998	0	502	652	0.963	1998	591	0	132	561	6775
1999	20	493	652	0.990	1999	607	22	136	551	6989
2000	19	453	651	0.954	2000	584	21	140	507	7227
2001	19	468	651	0.919	2001	563	21	145	523	7432
2002	39	374	651	0.885	2002	541	44	149	418	7747
2003	37	362	650	0.853	2003	521	41	155	405	8060
2004	36	443	650	0.822	2004	502	40	161	495	8268
2005	34	503	651	0.792	2005	484	38	165	563	8393
2006	33	518	647	0.763	2006	464	37	168	579	8482
2007	31	571	639	0.735	2007	442	35	170	639	8490
2008	30	681	621	0.708	2008	413	34	170	762	8344
2009	1174	726	592	0.682	2009	379	1313	167	812	9392
2010	15	561	571	0.657	2010	353	17	188	627	9322
2011	325	479	559	0.633	2011	332	363	186	536	9668
2012	0	511	551	0.610	2012	316	0	193	571	9606
2013	0	510	511	0.587	2013	282	0	192	570	9510
2014	0	552	446	0.566	2014	237	0	190	617	9320
2015	234	575	409	0.545	2015	210	262	186	643	9335
2016	0	532	387	0.525	2016	191	0	187	595	9117
2017	0	527	356	0.506	2017	169	0	182	589	8880
2018	23	526	337	0.488	2018	154	26	178	588	8649
2019		518	327	0.470	2019	145	0	173	579	8387
2020		521	319	0.452	2020	136	0	168	583	8108
2021		522	300	0.436	2021	123	0	162	584	7810
2022		518	283	0.420	2022	112	0	156	579	7498
2023		525	246	0.405	2023	93	0	150	587	7154
2024		522	201	0.390	2024	74	0	143	584	6787
2025		523	160	0.375	2025	56	0	136	585	6395
2026		527	103	0.362	2026	35	0	128	589	5968
2027		526	62	0.349	2027	20	0	119	588	5520

2028		519	39	0.336	2028	12	0	110	580	5062
2029		533	27	0.323	2029	8	0	101	596	4575
2030		521	19	0.312	2030	5	0	92	583	4089
2031		505	15	0.300	2031	4	0	82	565	3611
2032		520	15	0.289	2032	4	0	72	582	3105
2033		521	5	0.279	2033	1	0	62	583	2586
2034		378	0	0.268	2034	0	0	52	423	2215
2035		309		0.259	2035	0	0	44	346	1914
2036		291		0.249	2036	0	0	38	325	1627
2037		296		0.240	2037	0	0	33	331	1328
2038		244		0.231	2038	0	0	27	273	1082
2039		245		0.223	2039	0	0	22	274	829
2040		217		0.215	2040	0	0	17	243	603
2041		41		0.207	2041	0	0	12	46	570
2042		17		0.199	2042	0	0	11	19	562
2043		17		0.192	2043	0	0	11	19	554
2044		17		0.185	2044	0	0	11	19	546
2045		17		0.178	2045	0	0	11	19	538
2046		17		0.172	2046	0	0	11	19	530
2047		17		0.165	2047	0	0	11	19	521
2048		22		0.159	2048	0	0	10	25	507
2049		22		0.153	2049	0	0	10	25	493
2050		21		0.148	2050	0	0	10	23	479
2051		17		0.142	2051	0	0	10	19	470
2052		16		0.137	2052	0	0	9	18	461
2053		16		0.132	2053	0	0	9	18	453
2054		16		0.127	2054	0	0	9	18	444
2055		16		0.123	2055	0	0	9	18	435
2056		16		0.118	2056	0	0	9	18	426
2057		16		0.114	2057	0	0	9	18	416
2058		21		0.110	2058	0	0	8	23	401
2059		22		0.106	2059	0	0	8	25	384
2060		51		0.102	2060	0	0	8	57	335
2061		44		0.098	2061	0	0	7	49	293
2062		44		0.094	2062	0	0	6	49	249
2063		44		0.091	2063	0	0	5	49	205
2064		44		0.088	2064	0	0	4	49	160
2065		44		0.084	2065	0	0	3	49	114
2066		23		0.081	2066	0	0	2	26	90
2067		22		0.078	2067	0	0	2	25	68
2068		22		0.076	2068	0	0	1	25	44
2069		22		0.073	2069	0	0	1	25	21
2070		10		0.070	2070	0	0	0	11	10
2071		9		0.068	2071	0	0	0	10	0
Total	**2069**	**22829**	**15912**		**Total**	**11076**	**2314**	**6224**	**25532**	
(1995-2071)					**(1995-2071)**					

Table C.2
Nuclear Waste Program Funding Scenario 2
DOE With Synapse Reference Nuclear Projection

Real Interest Rate		2.000%								
Inflation		3.800%								
T&D		6.000%								
1994 EOY Fund		5291	(millions of 1994 $)							
Fee Through 1998		1.000	(nominal mills/kWh)							
Fee In 1999 and +		**1.156**	(nominal mills/kWh)							
Cost Reduction		2.8%			**DOE Fee Adequacy**					
					Summary of Nuclear Waste Fund Cash Flows					
					(In millions of 1997 Dollars)					
	One-Time Fee Payments (millions 1994$)	**Civilian Share of TSLCC (millions 1994$)**	**Nuclear Gener-ation (1000 GWH)**	**Fee (1997 mills/ kWh)**		**Mil Fee Payments**	**One-Time Fee Payments**	**Income From Investing**	**Civilian Share of TSLCC**	**EOY Fund Balance**
to 1994		3745			to 1994				4188	5917
1995	0	440	653	1.077	1995	661	0	118	492	6205
1996	0	472	653	1.038	1996	637	0	124	528	6438
1997	0	506	652	1.000	1997	613	0	129	566	6614
1998	0	502	678	0.963	1998	614	0	132	561	6799
1999	20	493	617	1.073	1999	623	22	136	536	7044
2000	19	453	594	1.034	2000	577	21	141	492	7290
2001	19	468	548	0.996	2001	513	21	146	509	7462
2002	39	374	506	0.960	2002	456	44	149	407	7704
2003	37	362	500	0.925	2003	434	41	154	394	7941
2004	36	443	500	0.891	2004	419	40	159	482	8077
2005	34	503	500	0.858	2005	403	38	162	547	8133
2006	33	518	499	0.827	2006	388	37	163	563	8157
2007	31	571	499	0.796	2007	374	35	163	621	8108
2008	30	681	499	0.767	2008	360	34	162	740	7923
2009	1174	726	491	0.739	2009	341	1313	158	789	8947
2010	15	561	485	0.712	2010	325	17	179	610	8857
2011	325	479	480	0.686	2011	310	363	177	521	9187
2012	0	511	479	0.661	2012	297	0	184	555	9113
2013	0	510	462	0.637	2013	277	0	182	554	9017
2014	0	552	415	0.613	2014	240	0	180	600	8837
2015	234	575	379	0.591	2015	211	262	177	625	8861
2016	0	532	378	0.569	2016	202	0	177	578	8662
2017	0	527	359	0.548	2017	185	0	173	573	8448
2018	23	526	352	0.528	2018	175	26	169	572	8246
2019		518	333	0.509	2019	159	0	165	563	8007
2020		521	331	0.490	2020	153	0	160	566	7753
2021		522	316	0.472	2021	140	0	155	567	7481
2022		518	285	0.455	2022	122	0	150	563	7190
2023		525	252	0.439	2023	104	0	144	571	6867
2024		522	230	0.422	2024	92	0	137	567	6528
2025		523	180	0.407	2025	69	0	131	569	6159
2026		527	148	0.392	2026	54	0	123	573	5764
2027		526	94	0.378	2027	34	0	115	572	5341
2028		519	51	0.364	2028	17	0	107	564	4901

2029		533	41	0.351	2029	14	0	98	579	4433
2030		521	25	0.338	2030	8	0	89	566	3963
2031		505	17	0.325	2031	5	0	79	549	3499
2032		520	17	0.313	2032	5	0	70	565	3008
2033		521	17	0.302	2033	5	0	60	566	2507
2034		378	9	0.291	2034	3	0	50	411	2149
2035		309	9	0.280	2035	2	0	43	336	1858
2036		291	9	0.270	2036	2	0	37	316	1581
2037		296	0	0.260	2037	0	0	32	322	1291
2038		244		0.251	2038	0	0	26	265	1052
2039		245		0.241	2039	0	0	21	266	806
2040		217		0.233	2040	0	0	16	236	586
2041		41		0.224	2041	0	0	12	45	554
2042		17		0.216	2042	0	0	11	18	546
2043		17		0.208	2043	0	0	11	18	539
2044		17		0.200	2044	0	0	11	18	531
2045		17		0.193	2045	0	0	11	18	523
2046		17		0.186	2046	0	0	10	18	515
2047		17		0.179	2047	0	0	10	18	507
2048		22		0.173	2048	0	0	10	24	493
2049		22		0.166	2049	0	0	10	24	479
2050		21		0.160	2050	0	0	10	23	466
2051		17		0.154	2051	0	0	9	18	457
2052		16		0.149	2052	0	0	9	17	448
2053		16		0.143	2053	0	0	9	17	440
2054		16		0.138	2054	0	0	9	17	431
2055		16		0.133	2055	0	0	9	17	423
2056		16		0.128	2056	0	0	8	17	414
2057		16		0.123	2057	0	0	8	17	405
2058		21		0.119	2058	0	0	8	23	390
2059		22		0.115	2059	0	0	8	24	374
2060		51		0.110	2060	0	0	7	55	326
2061		44		0.106	2061	0	0	7	48	284
2062		44		0.102	2062	0	0	6	48	242
2063		44		0.099	2063	0	0	5	48	199
2064		44		0.095	2064	0	0	4	48	155
2065		44		0.092	2065	0	0	3	48	111
2066		23		0.088	2066	0	0	2	25	88
2067		22		0.085	2067	0	0	2	24	66
2068		22		0.082	2068	0	0	1	24	43
2069		22		0.079	2069	0	0	1	24	20
2070		10		0.076	2070	0	0	0	11	10
2071		9		0.073	2071	0	0	0	10	0
Total	**2069**	**22829**	**14544**		**Total**	**10622**	**2314**	**6024**	**24877**	
(1995-2071)					**(1995-2071)**					

Table C.3
Nuclear Waste Program Funding Scenario 3
DOE With Synapse Low Nuclear Projection

Real Interest Rate		2.000%								
Inflation		3.800%								
T&D		6.000%								
1994 EOY Fund		5291	(millions of 1994 $)							
Fee Through 1998		1.000	(nominal mills/kWh)							
Fee In 1999 and +		**1.537**	(nominal mills/kWh)							
Cost Reduction		16.4%			**DOE Fee Adequacy**					
	One-	**Civilian**			**Summary of Nuclear Waste Fund Cash Flows**					
	Time	**Share**	**Nuclear**		**(In millions of 1997 Dollars)**					
	Fee Payments (millions 1994$)	**of TSLCC (millions 1994$)**	**Gener- ation (1000 GWH)**	**Fee (1997 mills/ kWh)**		**Mil Fee Payments**	**One- Time Fee Payments**	**Income From Investing**	**Civilian Share of TSLCC**	**EOY Fund Balance**
to 1994		3745			to 1994				4188	5917
1995	0	440	653	1.077	1995	661	0	118	492	6205
1996	0	472	653	1.038	1996	637	0	124	528	6438
1997	0	506	652	1.000	1997	613	0	129	566	6614
1998	0	502	673	0.963	1998	610	0	132	561	6795
1999	20	493	554	1.426	1999	742	22	136	461	7234
2000	19	453	498	1.374	2000	643	21	145	424	7620
2001	19	468	440	1.324	2001	548	21	152	438	7903
2002	39	374	262	1.275	2002	314	44	158	350	8069
2003	37	362	232	1.229	2003	268	41	161	338	8201
2004	36	443	231	1.184	2004	257	40	164	414	8248
2005	34	503	230	1.140	2005	247	38	165	470	8227
2006	33	518	223	1.099	2006	231	37	165	484	8175
2007	31	571	217	1.058	2007	216	35	164	534	8055
2008	30	681	207	1.020	2008	198	34	161	637	7812
2009	1174	726	187	0.982	2009	172	1313	156	679	8774
2010	15	561	185	0.946	2010	165	17	175	525	8607
2011	325	479	167	0.912	2011	143	363	172	448	8838
2012	0	511	166	0.878	2012	137	0	177	478	8674
2013	0	510	148	0.846	2013	118	0	173	477	8489
2014	0	552	136	0.815	2014	104	0	170	516	8246
2015	234	575	129	0.785	2015	95	262	165	538	8231
2016	0	532	128	0.757	2016	91	0	165	497	7989
2017	0	527	128	0.729	2017	88	0	160	493	7744
2018	23	526	127	0.702	2018	84	26	155	492	7517
2019		518	111	0.676	2019	70	0	150	484	7253
2020		521	101	0.652	2020	62	0	145	487	6973
2021		522	91	0.628	2021	54	0	139	488	6678
2022		518	80	0.605	2022	46	0	134	484	6373
2023		525	62	0.583	2023	34	0	127	491	6043
2024		522	60	0.561	2024	32	0	121	488	5708
2025		523	45	0.541	2025	23	0	114	489	5356
2026		527	44	0.521	2026	21	0	107	493	4992
2027		526	30	0.502	2027	14	0	100	492	4614

2028		519	16	0.484	2028	7	0	92	485	4229
2029		533	16	0.466	2029	7	0	85	498	3822
2030		521	9	0.449	2030	4	0	76	487	3415
2031		505	9	0.432	2031	3	0	68	472	3014
2032		520	8	0.417	2032	3	0	60	486	2591
2033		521	8	0.401	2033	3	0	52	487	2159
2034		378	8	0.387	2034	3	0	43	353	1852
2035		309	0	0.372	2035	0	0	37	289	1600
2036		291	0	0.359	2036	0	0	32	272	1360
2037		296	0	0.346	2037	0	0	27	277	1110
2038		244		0.333	2038	0	0	22	228	904
2039		245		0.321	2039	0	0	18	229	693
2040		217		0.309	2040	0	0	14	203	504
2041		41		0.298	2041	0	0	10	38	476
2042		17		0.287	2042	0	0	10	16	470
2043		17		0.276	2043	0	0	9	16	463
2044		17		0.266	2044	0	0	9	16	457
2045		17		0.257	2045	0	0	9	16	450
2046		17		0.247	2046	0	0	9	16	443
2047		17		0.238	2047	0	0	9	16	436
2048		22		0.229	2048	0	0	9	21	424
2049		22		0.221	2049	0	0	8	21	412
2050		21		0.213	2050	0	0	8	20	401
2051		17		0.205	2051	0	0	8	16	393
2052		16		0.198	2052	0	0	8	15	386
2053		16		0.190	2053	0	0	8	15	378
2054		16		0.183	2054	0	0	8	15	371
2055		16		0.177	2055	0	0	7	15	363
2056		16		0.170	2056	0	0	7	15	356
2057		16		0.164	2057	0	0	7	15	348
2058		21		0.158	2058	0	0	7	20	335
2059		22		0.152	2059	0	0	7	21	321
2060		51		0.147	2060	0	0	6	48	280
2061		44		0.141	2061	0	0	6	41	245
2062		44		0.136	2062	0	0	5	41	208
2063		44		0.131	2063	0	0	4	41	171
2064		44		0.126	2064	0	0	3	41	134
2065		44		0.122	2065	0	0	3	41	95
2066		23		0.117	2066	0	0	2	22	76
2067		22		0.113	2067	0	0	2	21	57
2068		22		0.109	2068	0	0	1	21	37
2069		22		0.105	2069	0	0	1	21	17
2070		10		0.101	2070	0	0	0	9	8
2071		9		0.097	2071	0	0	0	8	0
Total	**2069**	**22829**	**7924**		**Total**	**7768**	**2314**	**5698**	**21697**	
(1995-2071)					**(1995-2071)**					

Table C.4
Nuclear Waste Program Funding Scenario 4
Independent Cost Assessment

Real Interest Rate		2.000%								0
Inflation		3.800%								
T&D		6.000%								
1994 EOY Fund		5291	(millions of 1994 $)							
Fee Through 1998		1.000	(nominal mills/kWh)							
Fee In 1999 and +		**2.621**	(nominal mills/kWh)							
					Independent Cost Case					
	One-	**Civilian**			**Summary of Nuclear Waste Fund Cash Flows**					
	Time	**Share**	**Nuclear**		**(In millions of 1997 Dollars)**					
	Fee	**of**	**Gener-**	**Fee**			**One-**		**Civilian**	
	Payments	**TSLCC**	**ation**	**(1997**			**Time**	**Income**	**Share**	**EOY**
	(millions	**(millions**	**(1000**	**mills/**		**Mil Fee**	**Fee**	**From**	**of**	**Fund**
	1994$)	**1994$)**	**GWH)**	**kWh)**		**Payments**	**Payments**	**Investing**	**TSLCC**	**Balance**
to 1994		4016			to 1994				4491	5917
1995	0	399	653	1.077	1995	661	0	118	446	6251
1996	0	255	653	1.038	1996	637	0	125	285	6728
1997	0	321	652	1.000	1997	613	0	135	359	7117
1998	0	437	652	0.963	1998	591	0	142	489	7362
1999	20	492	652	2.433	1999	1491	22	147	550	8472
2000	19	680	651	2.344	2000	1434	21	169	761	9336
2001	19	510	651	2.258	2001	1382	21	187	571	10355
2002	39	783	651	2.175	2002	1330	44	207	876	11060
2003	37	1134	650	2.095	2003	1281	41	221	1268	11335
2004	36	899	650	2.019	2004	1234	40	227	1006	11830
2005	34	1366	651	1.945	2005	1190	38	237	1528	11766
2006	33	1548	647	1.874	2006	1139	37	235	1731	11446
2007	31	1311	639	1.805	2007	1085	35	229	1467	11328
2008	30	1523	621	1.739	2008	1015	34	227	1703	10899
2009	1174	802	592	1.675	2009	932	1313	218	897	12465
2010	15	759	571	1.614	2010	867	17	249	849	12749
2011	325	796	559	1.555	2011	817	363	255	890	13294
2012	0	767	551	1.498	2012	776	0	266	858	13477
2013	0	772	511	1.443	2013	694	0	270	863	13578
2014	0	726	446	1.390	2014	582	0	272	812	13619
2015	234	785	409	1.339	2015	515	262	272	878	13790
2016	0	768	387	1.290	2016	469	0	276	859	13676
2017	0	786	356	1.243	2017	416	0	274	879	13487
2018	23	787	337	1.198	2018	379	26	270	880	13281
2019		809	327	1.154	2019	355	0	266	905	12998
2020		798	319	1.112	2020	334	0	260	892	12699
2021		788	300	1.071	2021	302	0	254	882	12374
2022		798	283	1.032	2022	274	0	247	893	12003
2023		915	246	0.994	2023	229	0	240	1023	11449
2024		813	201	0.957	2024	181	0	229	909	10950
2025		852	160	0.922	2025	139	0	219	953	10355
2026		825	103	0.889	2026	86	0	207	923	9725
2027		868	62	0.856	2027	50	0	194	971	8999

2028		836	39	0.825	2028	30	0	180	935	8273
2029		840	27	0.795	2029	20	0	165	939	7520
2030		823	19	0.765	2030	13	0	150	921	6763
2031		700	15	0.737	2031	10	0	135	783	6126
2032		1116	15	0.710	2032	10	0	123	1248	5010
2033		585	5	0.684	2033	3	0	100	654	4460
2034		422	0	0.659	2034	0	0	89	472	4077
2035		448		0.635	2035	0	0	82	501	3657
2036		396		0.612	2036	0	0	73	443	3287
2037		396		0.590	2037	0	0	66	443	2910
2038		398		0.568	2038	0	0	58	445	2523
2039		337		0.547	2039	0	0	50	377	2197
2040		124		0.527	2040	0	0	44	139	2101
2041		61		0.508	2041	0	0	42	69	2075
2042		44		0.489	2042	0	0	41	49	2067
2043		58		0.471	2043	0	0	41	65	2044
2044		44		0.454	2044	0	0	41	50	2035
2045		30		0.438	2045	0	0	41	34	2042
2046		29		0.421	2046	0	0	41	32	2051
2047		30		0.406	2047	0	0	41	33	2058
2048		38		0.391	2048	0	0	41	42	2057
2049		35		0.377	2049	0	0	41	39	2058
2050		34		0.363	2050	0	0	41	38	2061
2051		27		0.350	2051	0	0	41	30	2073
2052		59		0.337	2052	0	0	41	66	2049
2053		26		0.325	2053	0	0	41	29	2061
2054		26		0.313	2054	0	0	41	29	2074
2055		29		0.301	2055	0	0	41	33	2083
2056		25		0.290	2056	0	0	42	28	2096
2057		25		0.280	2057	0	0	42	28	2110
2058		34		0.269	2058	0	0	42	38	2114
2059		35		0.260	2059	0	0	42	40	2117
2060		307		0.250	2060	0	0	42	343	1816
2061		259		0.241	2061	0	0	36	289	1563
2062		259		0.232	2062	0	0	31	289	1305
2063		259		0.224	2063	0	0	26	289	1042
2064		259		0.215	2064	0	0	21	289	773
2065		259		0.208	2065	0	0	15	289	499
2066		116		0.200	2066	0	0	10	129	380
2067		104		0.193	2067	0	0	8	116	271
2068		104		0.186	2068	0	0	5	116	160
2069		104		0.179	2069	0	0	3	116	47
2070		25		0.172	2070	0	0	1	28	21
2071		19		0.166	2071	0	0	0	21	0
Total	**2069**	**37055**	**15912**		**Total**	**23565**	**2314**	**9646**	**41442**	
(1995-2071)					**(1995-2071)**					

Table C.5
Nuclear Waste Program Funding Scenario 5
Independent Cost Assessment With Synapse Reference Nuclear Projection

Real Interest Rate		2.000%								
Inflation		3.800%								
T&D		6.000%								
1994 EOY Fund		5291	(millions of 1994 $)							
Fee Through 1998		1.000	(nominal mills/kWh)							
Fee In 1999 and +		**2.905**	(nominal mills/kWh)							
Cost Reduction		2.8%			**DOE Fee Adequacy DRI Case**					
	One-Time Fee Payments (millions 1994$)	**Civilian Share of TSLCC (millions 1994$)**	**Nuclear Gener-ation (1000 GWH)**	**Fee (1997 mills/ kWh)**	**Summary of Nuclear Waste Fund Cash Flows (In millions of 1997 Dollars)**					
						Mil Fee Payments	**One-Time Fee Payments**	**Income From Investing**	**Civilian Share of TSLCC**	**EOY Fund Balance**
to 1994		4016			to 1994				4491	5917
1995	0	399	653	1.077	1995	661	0	118	446	6251
1996	0	255	653	1.038	1996	637	0	125	285	6728
1997	0	321	652	1.000	1997	613	0	135	359	7117
1998	0	437	678	0.963	1998	614	0	142	489	7385
1999	20	492	617	2.696	1999	1564	22	148	535	8584
2000	19	680	594	2.597	2000	1449	21	172	739	9487
2001	19	510	548	2.502	2001	1290	21	190	555	10433
2002	39	783	506	2.411	2002	1146	44	209	852	10980
2003	37	1134	500	2.323	2003	1091	41	220	1233	11100
2004	36	899	500	2.238	2004	1051	40	222	978	11435
2005	34	1366	500	2.156	2005	1013	38	229	1485	11230
2006	33	1548	499	2.077	2006	975	37	225	1682	10784
2007	31	1311	499	2.001	2007	939	35	216	1426	10548
2008	30	1523	499	1.927	2008	904	34	211	1655	10041
2009	1174	802	491	1.857	2009	857	1313	201	872	11539
2010	15	759	485	1.789	2010	816	17	231	825	11777
2011	325	796	480	1.723	2011	778	363	236	865	12289
2012	0	767	479	1.660	2012	747	0	246	834	12448
2013	0	772	462	1.600	2013	695	0	249	839	12553
2014	0	726	415	1.541	2014	602	0	251	790	12616
2015	234	785	379	1.485	2015	529	262	252	853	12806
2016	0	768	378	1.430	2016	508	0	256	835	12736
2017	0	786	359	1.378	2017	465	0	255	855	12601
2018	23	787	352	1.327	2018	439	26	252	855	12463
2019		809	333	1.279	2019	400	0	249	879	12233
2020		798	331	1.232	2020	383	0	245	867	11994
2021		788	316	1.187	2021	352	0	240	857	11730
2022		798	285	1.143	2022	307	0	235	868	11403
2023		915	252	1.102	2023	261	0	228	995	10897
2024		813	230	1.061	2024	230	0	218	884	10462
2025		852	180	1.022	2025	173	0	209	926	9918
2026		825	148	0.985	2026	137	0	198	897	9356

2027		868	94	0.949	2027	84	0	187	943	8684
2028		836	51	0.914	2028	43	0	174	909	7992
2029		840	41	0.881	2029	34	0	160	913	7273
2030		823	25	0.848	2030	20	0	145	895	6544
2031		700	17	0.817	2031	13	0	131	761	5927
2032		1116	17	0.787	2032	12	0	119	1213	4845
2033		585	17	0.759	2033	12	0	97	636	4318
2034		422	9	0.731	2034	6	0	86	459	3951
2035		448	9	0.704	2035	6	0	79	487	3549
2036		396	9	0.678	2036	6	0	71	431	3195
2037		396	0	0.654	2037	0	0	64	431	2828
2038		398		0.630	2038	0	0	57	432	2452
2039		337		0.607	2039	0	0	49	366	2135
2040		124		0.584	2040	0	0	43	135	2043
2041		61		0.563	2041	0	0	41	67	2017
2042		44		0.542	2042	0	0	40	48	2009
2043		58		0.522	2043	0	0	40	63	1987
2044		44		0.503	2044	0	0	40	48	1978
2045		30		0.485	2045	0	0	40	33	1985
2046		29		0.467	2046	0	0	40	32	1993
2047		30		0.450	2047	0	0	40	33	2000
2048		38		0.434	2048	0	0	40	41	1999
2049		35		0.418	2049	0	0	40	38	2001
2050		34		0.402	2050	0	0	40	37	2004
2051		27		0.388	2051	0	0	40	29	2015
2052		59		0.374	2052	0	0	40	64	1991
2053		26		0.360	2053	0	0	40	28	2003
2054		26		0.347	2054	0	0	40	28	2016
2055		29		0.334	2055	0	0	40	32	2024
2056		25		0.322	2056	0	0	40	27	2038
2057		25		0.310	2057	0	0	41	27	2051
2058		34		0.299	2058	0	0	41	37	2055
2059		35		0.288	2059	0	0	41	38	2058
2060		307		0.277	2060	0	0	41	334	1765
2061		259		0.267	2061	0	0	35	281	1519
2062		259		0.257	2062	0	0	30	281	1268
2063		259		0.248	2063	0	0	25	281	1012
2064		259		0.239	2064	0	0	20	281	752
2065		259		0.230	2065	0	0	15	281	485
2066		116		0.222	2066	0	0	10	126	369
2067		104		0.213	2067	0	0	7	113	264
2068		104		0.206	2068	0	0	5	113	156
2069		104		0.198	2069	0	0	3	113	46
2070		25		0.191	2070	0	0	1	27	20
2071		19		0.184	2071	0	0	0	21	0
Total	**2069**	**37055**	**14544**		**Total**	**22865**	**2314**	**9229**	**40326**	
(1995-2071)					**(1995-2071)**					

Table C.6
Nuclear Waste Program Funding Scenario 6
Independent Cost Assessment With Synapse Low Nuclear Projection

Real Interest Rate		2.000%								
Inflation		3.800%								
T&D		6.000%								
1994 EOY Fund		5291	(millions of 1994 $)							
Fee Through 1998		1.000	(nominal mills/kWh)							
Fee In 1999 and +		**4.454**	(nominal mills/kWh)							
Cost Reduction		16.4%			**DOE Fee Adequacy DRI Case**					
	One-Time Fee Payment (millions 1994$)	**Civilian Share of TSLCC (million 1994$)**	**Nuclear Gener-ation (1000 GWH)**	**Fee (1997 mills/ kWh)**	**Summary of Nuclear Waste Fund Cash Flows (In millions of 1997 Dollars)**	**Mil Fee Payment**	**One-Time Fee Payment**	**Income From Investin**	**Civilian Share of TSLCC**	**EOY Fund Balance**
to 1994		4016			to 1994				4491	5917
1995	0	399	653	1.077	1995	661	0	118	446	6251
1996	0	255	653	1.038	1996	637	0	125	285	6728
1997	0	321	652	1.000	1997	613	0	135	359	7117
1998	0	437	673	0.963	1998	610	0	142	489	7381
1999	20	492	554	4.134	1999	2151	22	148	460	9242
2000	19	680	498	3.982	2000	1864	21	185	636	10676
2001	19	510	440	3.836	2001	1587	21	214	477	12021
2002	39	783	262	3.696	2002	909	44	240	732	12482
2003	37	1134	232	3.561	2003	775	41	250	1060	12488
2004	36	899	231	3.430	2004	745	40	250	841	12682
2005	34	1366	230	3.305	2005	715	38	254	1277	12411
2006	33	1548	223	3.184	2006	668	37	248	1447	11918
2007	31	1311	217	3.067	2007	625	35	238	1226	11590
2008	30	1523	207	2.955	2008	575	34	232	1424	11007
2009	1174	802	187	2.847	2009	499	1313	220	750	12289
2010	15	759	185	2.743	2010	478	17	246	710	12320
2011	325	796	167	2.642	2011	415	363	246	744	12601
2012	0	767	166	2.545	2012	398	0	252	717	12533
2013	0	772	148	2.452	2013	341	0	251	722	12404
2014	0	726	136	2.362	2014	302	0	248	679	12275
2015	234	785	129	2.276	2015	276	262	245	734	12324
2016	0	768	128	2.193	2016	265	0	246	718	12117
2017	0	786	128	2.112	2017	254	0	242	735	11879
2018	23	787	127	2.035	2018	244	26	238	736	11650
2019		809	111	1.961	2019	204	0	233	756	11331
2020		798	101	1.889	2020	178	0	227	746	10990
2021		788	91	1.820	2021	156	0	220	737	10629
2022		798	80	1.753	2022	132	0	213	746	10228
2023		915	62	1.689	2023	98	0	205	855	9675
2024		813	60	1.627	2024	92	0	193	760	9201
2025		852	45	1.567	2025	66	0	184	796	8654
2026		825	44	1.510	2026	62	0	173	772	8118

2027		868	30	1.455	2027	41	0	162	811	7510
2028		836	16	1.402	2028	21	0	150	782	6899
2029		840	16	1.350	2029	20	0	138	785	6272
2030		823	9	1.301	2030	10	0	125	770	5639
2031		700	9	1.253	2031	10	0	113	655	5107
2032		1116	8	1.207	2032	9	0	102	1043	4175
2033		585	8	1.163	2033	9	0	83	547	3720
2034		422	8	1.121	2034	8	0	74	395	3408
2035		448	0	1.080	2035	0	0	68	419	3057
2036		396	0	1.040	2036	0	0	61	370	2748
2037		396	0	1.002	2037	0	0	55	371	2432
2038		398		0.965	2038	0	0	49	372	2109
2039		337		0.930	2039	0	0	42	315	1836
2040		124		0.896	2040	0	0	37	116	1757
2041		61		0.863	2041	0	0	35	57	1735
2042		44		0.831	2042	0	0	35	41	1728
2043		58		0.801	2043	0	0	35	54	1709
2044		44		0.772	2044	0	0	34	41	1701
2045		30		0.743	2045	0	0	34	28	1707
2046		29		0.716	2046	0	0	34	27	1714
2047		30		0.690	2047	0	0	34	28	1721
2048		38		0.665	2048	0	0	34	35	1719
2049		35		0.640	2049	0	0	34	33	1721
2050		34		0.617	2050	0	0	34	32	1723
2051		27		0.594	2051	0	0	34	25	1733
2052		59		0.573	2052	0	0	35	55	1713
2053		26		0.552	2053	0	0	34	24	1723
2054		26		0.531	2054	0	0	34	24	1734
2055		29		0.512	2055	0	0	35	27	1741
2056		25		0.493	2056	0	0	35	23	1753
2057		25		0.475	2057	0	0	35	23	1764
2058		34		0.458	2058	0	0	35	32	1768
2059		35		0.441	2059	0	0	35	33	1770
2060		307		0.425	2060	0	0	35	287	1518
2061		259		0.409	2061	0	0	30	242	1307
2062		259		0.394	2062	0	0	26	242	1091
2063		259		0.380	2063	0	0	22	242	871
2064		259		0.366	2064	0	0	17	242	646
2065		259		0.353	2065	0	0	13	242	418
2066		116		0.340	2066	0	0	8	108	318
2067		104		0.327	2067	0	0	6	97	227
2068		104		0.315	2068	0	0	5	97	134
2069		104		0.304	2069	0	0	3	97	40
2070		25		0.293	2070	0	0	1	23	17
2071		19		0.282	2071	0	0	0	18	0
Total	**2069**	**37055**	**7924**		**Total**	**17728**	**2314**	**8945**	**34904**	
	(1995-2071)				**(1995-2071)**					