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COSTS AND FINANCING OF REACTOR DECOMMISSIONING: SOME CONSIDERATIONS

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ESTIMATES OF DECOMMISSIONING COSTS

Despite the paucity of actual decommissioning experience and the lack of detailed, specific decommissioning procedures, estimates of the costs of completely dismantling a power reactor have been ventured, as seen in Figures 1 and 2. These figures present some interesting conclusions:

- o Utility estimates for today's larger reactors (700-900 MWe) tend to range from $50 to $100 million (in today's dollars) for total dismantling.
- o Estimates by federal authorities or contractors associated with federal agencies tend to be much lower than utility estimates.
- o The widely-quoted Atomic Industrial Forum (AIF) study produced the lowest estimates ($27-31 million) of all those collected.

Implications. It is difficult to gather information on the detailed analyses underlying most of the cost estimates presented. Credibility varies: some of these estimates are probably based on little more than simple extrapolation from or repetition of the estimates provided by others, while other estimates (for example, those for San Onofre 1 and those in the AIF report) appear to have been the result of substantial analytical effort.

Further effo.ts wil be required to determine more fully the assumptions behind the estimates and possible deficiencies.

As noted, the utility estimates indicated that decommissioning a new 1,000 MWe reactor would cost more than $100 million. This is three times the AIF estimate (see Figure 2) and higher than those of the governmental entities or their contractors. Future study on the financing of decommissioning might attempt to verify these cost estimates and determine the re sons for the non-uniformity.

Problem Area: Uncertainty in Cost Estimates

A large degree of uncertainty exists in today's estimates of the costs of decontaminating and decommissioning reactors and this uncertainty grows as costs are estimated for dates in the future.

Cost estimates are uncertain because of the uncertainties in the exact procedures involved, the relevant regulatory requirements, the future costs of labor and materials, and the lack of relevant experience.

The NRC is attempting to develop procedures for decommissioning reactors and a report on pressurized water reactors was released last June (NUREG/CR-0130). The development of detailed and specific procedures and relevant health standards (e.g., bulk material standards) plus the accumulation of additional experience will all help to decrease the present cost uncertainties.

FIGURE 1
UTILITY COST ESTIMATES FOR DECOMMISSIONING (COMPLETE DISMANTLING)

Plant Operator Location	Reactor Size (MWe)	Reactor Type	First Operation	Dollar Cost (Millions)	% of Original Cost
Beaver Valley I Duquesne Light Shippingport, Pa.	852	PWR	1976	$ 50[a]	10%[a]
Three Mile Island I Met. Ed., JCP&L, Penn. El. Goldsboro, Pa.	792	PWR	1974	$ 95.8('77)[b]	
Three Mile Island II Met. Ed., Penn. El. Goldsboro, Pa.	880	PWR	1978	$ 94.5('77)[b]	
Turkey Point III Florida P&L Florida City, Fla.	666	PWR	1972	$100[c]	19%[d]
Millstone I Northeast Utilities Waterford, Conn.	652	BWR	1970	$ 59.5[e]	
Millstone II Northeast Utilities Waterford, Conn.	828	PWR	1975	$ 59[e]	
Connecticut Yankee Northeast Utilities Haddon Neck, Conn.				$48.7[e]	
Farley I Alabama Power Dothan, Ala.	860	PWR	1977	$100[c]	
Brunswick I Caroline P&L Southport, N.C.	821	BWR	1977	$128.5[c]	
Arkansas Nuclear I Arkansas P&L Russellville, Ark.	836	PWR	1974	$100[c]	
St. Lucie I Florida P&L Hutchinson Is., Fla.	803	PWR	1976	$100[c]	
Hatch I Georgia Power Baxley, Ga.	786	BWR	1975	$100[c]	

FIGURE 1
(Continued)

Plant Operator Location	Reactor Size (MWe)	Reactor Type	First Operation	Dollar Cost (Millions)	% of Original Cost
Calvert Cliffs I Baltimore G&E Lusby, Md.	850	PWR	1975	$100[c]	
North Anna I Virginia Elec. & Power Mineral, Va.	934	PWR	1978	$ 75[f]	
San Onofre 1 SCE, SDG&E San Clemente, Ca.	436	PWR	1968	$ 63-78 ('77)[g]	
Diablo Canyon 1 PG&E Diablo Canyon, Ca.	1060	PWR	1978	$ 35 (no contamination considered)[h]	

SOURCES

a. Duquesne Light's Statement 11-1 before the Pennsylvania Public Utility Commission, RID 373, pp. 24-25, gives the utility's share (47.5 percent) of Beaver Valley I decommissioning at $24,275,675.

b. Updated cost estimate, May 20, 1977, by W. A. Verrochi in Pennsylvania Electric's Statement No. 4, Exhibit 4-D-1, before the Pennsylvania PUC, RID 392.

c. Testimony of G. R. Faust, Gilbert Associates, Inc., before the Connecticut Public Utility Commission on the matter of providing for the costs of decommissioning Millstone I and II.

d. Letter from William B. DeMilly, Florida Public Service Commission, to Ben H. Fuqua, Vice President, Florida Power and Light, April 3, 1974.

e. Nucleonics Week, January 6, 1977, pp. 5-6.

f. Final Environmental Impact Statement, April 1973, Nuclear Regulatory Commission, Docket 50-338, p. 8-8.

g. R. Jon Stouky and E. J. Ricer, San Onofre Nuclear Generating Station Decommissioning Alternatives, Report 1851, for Southern California Edison (NUS Corp., February 1977).

h. Testimony of Peter N. Skinner, New York State Law Department, to the New York Public Service Commission, Case No. 26974, December 2, 1977, p. 21.

FIGURE 2
GOVERNMENT AND INDUSTRY COST ESTIMATES FOR DECOMMISSIONING

Reactor Size (MWe)	Reactor Type	Dollar Cost (Millions)	% of Original Cost
1100	PWR	\$27('75)[a]	
1100	BWR	\$31('75)[a]	
*	*	\$25-50[b]	
*	*	\$36-60[c]	
1000	*	\$35-50('76)[d]	
1150	*	*	24%[e]
1175	PWR	\$42('78)[f]	

*Not specified.

SOURCES

a. William J. Manion and Thomas S. LaGuardia, An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives, AIR/NESP-009SR (Atomic Industrial Forum, National Environmental Studies Project, November 1976).

b. Nucleonics Week, January 26, 1978, p. 15.

c. General Accounting Office, RED-76-7.

d. K. M. Harmon et al., "Decommissioning Nuclear Facilities", in Proceedings of the International Symposium on the Management of Wastes from the LWR Fuel Cycle, CONF 76-0701, sponsored by the Energy Research and Development Administration, Denver, Colo., July 1976.

e. See Figure 1, reference (h).

f. R. I. Smith et al., Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station, NUREG/CR-0130, U.S. Nuclear Regulatory Commission, June, 1978.

FINANCING THE DECOMMISSIONING OF REACTORS

Reasons for Special Financing of Decommissioning

Three factors argue that special efforts to provide for the eventual costs of decommissioning are warranted and necessary: the substantial costs involved in decommissioning, the necessity for equitable treatment of ratepayers, and the possibility of utility insolvency in the distant future.

1. Large Costs. The costs of decommissioning one of today's commercial reactors are a substantial expense for a utility to incur. Even at today's prices, costs could run to more than $100 million and complete dismantlement could take six to seven years to complete.[1] Any financing mechanism should provide for inflation, which, given a reasonable estimate of 4 to 8 percent per year, might increase the costs to from $300 million to $1 billion during the life of today's new reactors.*

2. Equitable Treatment of Ratepayers. Because the costs of decommissioning are large and because these costs are the direct and predictable result of operating a reactor to produce electricity, consideration should be given as to who should pay for the expense of decommissioning. If no mechanism is implemented to provide for the costs of decommissioning before the money is needed, the ratepayers of a utility at the time of decommissioning might be burdened with the costs of decommissioning a shutdown reactor from which they have derived little benefit (i.e., elecricity). Since present knowledge and experience can enable us to anticipate and to estimate of the costs of decommissioning, it would not be unfair to expect the consumers of nuclear power to pay the costs of decommissioning the plant. This can best be accomplished by collecting funds for this purpose during the operating life of the reactor by means of some financing mechanism.

3. Utility Solvency in the Distant Future. While the cost of decommissioning a reactor today might be a substantial expense, few commercial reactors may actually require decommissioning in the near future. Decommissioning of today's reactors may not take place until 30 to 130 years from now.** Therefore, the future ability of utilities to pay the future costs of decommissioning may be the more important issue. As a result, consideration should be given to the possibility that a utility, while perhaps capable of handling the expense today, may be unable, because of unforeseen future financial and/or economic events, to meet the costs of decommissioning (inflated over time) at that point in the future when decommissioning is most likely to be necessary. If in the future a utility with a decommissioning obligation is no longer present as a corporate or public entity, or is insolvent or otherwise unable to provide the necessary monies, the

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*Inflation rates of 4 to 8 percent, when compounded annually for 30 years, would produce cost increases of 224 percent and 906 percent, respectively. A decommissioning that costs $100 million today would, using these inflation rates, cost between $324 million and $1.009 billion 30 years from now.

**Range results from the possible inclusion of a 0-100 year delay to permit the decay of short-lived radionuclides added to an anticipated 30-year operating life.

Figure 3
MECHANISMS FOR FINANCING DECOMMISSIONING

Financing Mechanism	Who Pays	Handles Changing Cost Estimates	Accumulated Funds at Premature Shutdown	Funds Availability at Shutdown
1. Expensed - Costs expensed when they are incurred. Pennsylvania PUC method.	Ratepayers at time of retirement.	No	None	None
2a. Lump Sum Funded Account - Lump sum of cash deposited at reactor start in investment account. Principal plus accumulated interest will cover estimated cost.	Ratepayers at beginning of service.	Not without additions to principal.	Some, but full amount not accum. until anticipated shutdown.	Funds exist as liquid assets.
2b. Sinking Fund Account - Equal installments of cash are deposited each year of plant operation. Principal plus accumulated interest will cover estimated cost. (Duquesne Light - Beaver Valley I proposal)	Ratepayers at time of service.	Can be periodically readjusted.	Some, but full amount not accum. until anticipated shutdown.	Funds exist as liquid assets.
3. SLRL Depreciation Account - Estimated costs are depreciated over plant life by straight line remaining life method.	Ratepayers at time of service.	Can be periodically readjusted.	Some, but full amount not accum. until anticipated shutdown.	Funds exist onl on books of uti depend on incom time of shutdow
4a. Premature Shutdown Insurance - Bond is purchased to cover the decreasing difference between the funds accumulated by some other mechanism and the estimated cost at that point in time.	Stockholders or ratepayers at time of service.	Can be periodically readjusted.	Guarantees through third party insurer that full funds available at any time.	Insurance value decreases to ze at anticipated shutdown.
4b. Surety Bond - Bond is purchased to guarantee that monies equivalent to those collected by a depreciation mechanism will be available at the time of decommissioning.	Stockholders or ratepayers at time of service.	Indirectly, through adjustments of depreciation mechanism.	Guarantees only that monies accum. by depreciation will be available, though these may be insufficient.	Guarantees that funds accumulat by another mech will be availab as liquid asset when needed.

liability will probably fall to the state or the federal government. It may be wise to protect against such a situation by the implementation at the outset of reactor operation of a mechanism to ensure that the necessary monies will be available when needed in the future.

In conclusion, it seems reasonable that one requirement for any acceptable financing mechanism is that, in a fair and equitable manner, it collects from the consumers of the power the cost of decommissioning the power source before the need occurs in a manner which reflects the true cost of providing the power.

Availability of Funds at Time of Decommissioning.

Having established that some financing mechanism is required, the preceding argument regarding the future solvency of utilities also has implications for the type of mechanism chosen. In the event that provision was not made to cover the costs of decommissioning, a utility on shaky financial ground might have a difficult time extracting the necessary monies from its operating revenues at the time when the wo k is to be performed. Even if the regulatory agency at that future time were to permit the utility to obtain the necessary monies from the ratepayers, the large amounts of money involved might further weaken the financial position of such a utility.

While it is possible that all utilities will still exist and be solvent at the time of decommissioning, this cannot be assured. Recent years have seen the financial position of many utilities slip substantially, from New York's giant Copnsolidated Edison to smaller utilities such as Public Service of New Hampshire and California's own San Diego Gas & Electric.* Given the period of time that will pass before today's new reactors may require decommissioning, it may be unwise to assume that all reactor operators will be able to remain financially secure. Additional unforeseen events might also weaken an individual utility. If a smaller utility with a large investment in one or two reactors was to experience an accident, earthquake, or other catastrophic event that damaged its reactor, the utility might, in short order, find itself the possessor of an inoperative, non-revenue-producing reactor in need of immediate decommissioning.

In light of the possiblity of future utility insolvency, it can be argued that in the selection of financing mechanisms for decommissioning the anticipted future solvency of the reactor operator should be carefully examined. A future situation in which a utility might be unable to pay for decommissioning costs directly out of future revenue (see "Expensed" funding mechanism in Figure 3) might be the same situation in which it would be unable to shift future revenue to pay for decommissioning funds that are in a depreciation account on the

*In 1974 Con Ed issued no dividends on its common stock and sold nuclear facilities to another power company to maintain stability. The ability of SDG&E to support a major share of the Sundesert Nuclear Project was officially challenged by the California Public Utilities Commission in May 1978 in its refusal to allow the utility to increase its rates to pay for Sundesert; SDG&E subsequently killed the project. For details on the case of Public Service of New Hampshire, see Nucleonics Week, December 8, 1977.

company's books (see SLRL Depreciation Account mechanism in Figure 3). It could be argued that if uncertain future events justify the imposition of any financing mechanism, then they justify the imposition of one that does not depend on utility operating revenues at the time of decommissioning as the source of actual decommissioning monies.

An additional wrinkle is added to the problem of providing decommissioning funds if one considers the time interval between reactor shutdown and the actual dismantlement of the reactor. Assume that some mechanism has accumulated decommissioning monies from the consumers of the reactor's power. After the reactor is retired and shut down, no more money should be extracted from the ratepayers, in keeping with the previous arguments regarding their equitable treatment. Yet even if reactor decommissioning proceeded at a maximum pace, it might be 10 years after shutdown before the work would be completed. The AIF study suggested a delay of 100 years after shutdown before dismantlement should be attempted, to permit a decrease of radiation levels. Whatever funds have been accumulated must, therefore, be capable of covering the costs of decommissioning not at the time of shutdown but at times at least 10 years after shutdown and perhaps as much as 100 years after shutdown. If, after reactor shutdown, the decommissioning costs continue to inflate (in line with general prevailing inflationary trends), either more monies will have to be extracted from non-benefited ratepayers or else the accumulated monies must be able to grow by some other means in order to keep up with inflation. This other means might be the investment of these funds in income-producing securities or some similar mechanism. If financing for decommissioning during operation were accomplished by use of depreciation, for eample, it might at shutdown, by the above reasoning, be necessary to transfer the accumulated monies into incoming producing securities. Had a sinking fund been employed initially, rather than a deprecition account, the accumulated monies would already be in such a form at reactor shutdown.

In conclusion, there are reasons why one might want to select a financing mechanism of the kind that sets aside liquid assets rather than one that sets aside funds only on the company books, which must be supplied by future revenues. However, the cost of the various alternative financing methods may also impact the decision as to which method is selected.

Premature Shutdown.

Even though a financing mechanism may be capable of accumulating the necessary monies for decommissioning by the end of a reactor's estimated life, the mechanism may still be inadequate. It is the nature of most proposed financing mechanisms that they accumulate funds in an exponential fashion over time (see Figure 5). As a result, the accumulated reserve funds approach the costs of decommissioning only at the end of the estimated reactor life and are appreciably below the required amount until the final expected years of operation. Thus, if the estimate of the length of reactor lifetime is in error and shutdown comes prematurely, the accumulated assets may fall substantially short of the amount required to completely decommission at that time.

The life expectancy of a reactor may be shortened for a number of reasons. In California, the Humboldt Bay reactor is being considered for permanent shutdown because of the recent discovery of suspected earthquake faults near the site.[2]

This reactor is only 14 years into its expected 30-year life. The Dresden I reactor in Illinois, while only 17 years old, has high levels of in-plant radiation that have curtailed the operator's ability to perform routine maintenance; unless costly decontamination is successful it too may have to be prematurely retired. An accident such as the partial core meltdown at the Fermi I plant in Michigan might force premature shutdown. Even accidents tht do not greatly threaten public safety may be so costly to repair that shutdown may be economically preferable.

The assumption that all reactors will meet the anticipated operating life of 30 to 40 years may not be made with certainty insofar as there has been insufficient long-term experience in this area. No commercial reactor has operated this long. In fact, the whole industry is hardly 30 years old. Given our brief experience, the question of the accuracy of estimates of reactor lifetime(s) is a legitimate one.

Since there appears to be reason for doubt regarding the absolute reliability of reactor lifetime estimates, the question arises as to how financing mechanisms might protect ratepayers or the public in general from the need to make up the deficit in accumulated decommissioning funds in a case of premature shutdown. Whatever financing procedure is adopted should be capable of providing sufficient monies to decommission even if the reactor is forced to shut down prematurely.

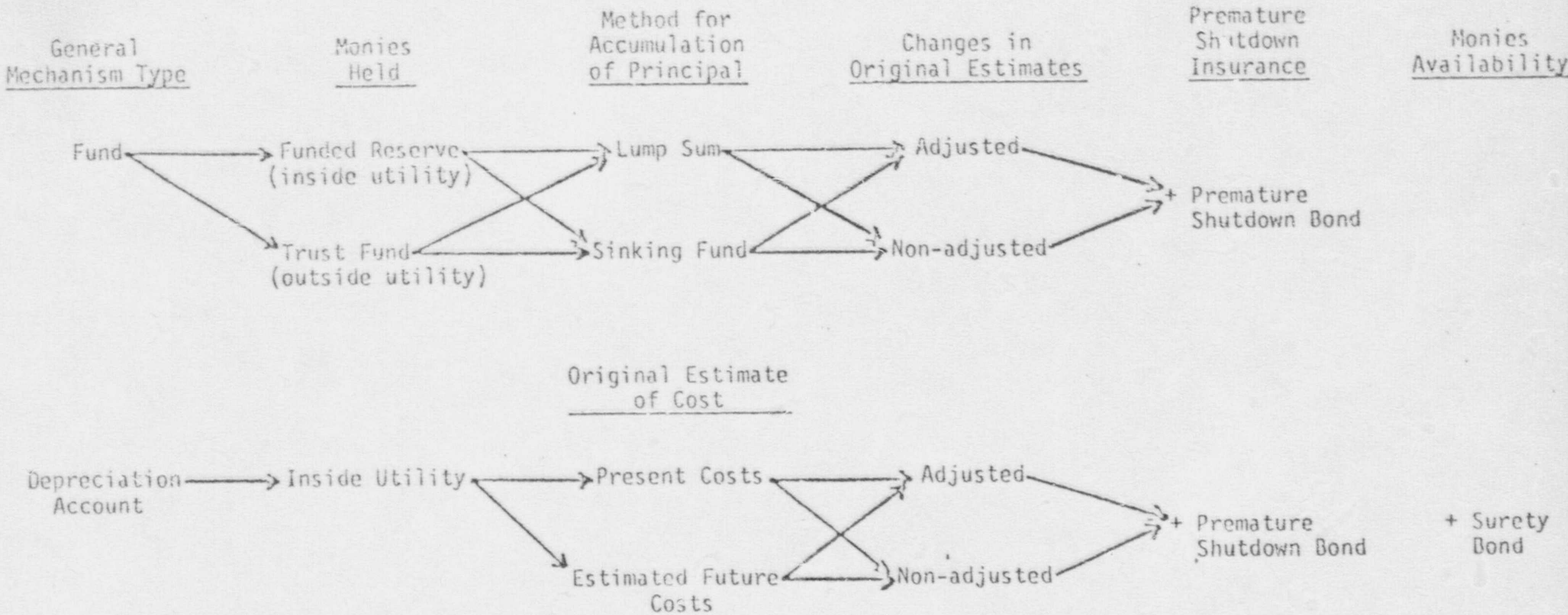
Uncertain Estimates.

Assuming for the moment that an estimate has been made of the cost of decommissioning a particular reactor at some expected future date and that a mechanism has been devised to collect the required monies by the predicted time of shutdown and at all times in between in case of premature shutdown, what other requirements might be warranted? A financing mechanism should be capable of accommodating errors not only in the estimated reactor lifespan but also in the original estimate of decommissioning costs.

The initial estimate of decommissioning costs may be predicated on certain assumptions regarding the inflation rate between now and shutdown, the relevant government regulations that will be in the force at shutdown, and the procedures that will be followed and the technology that will be employed to accomplish this decommissioning. All of these factors (and others) can and will quite likely change between now and the time of decommissioning.

Such uncertainties have led some to argue that the uncertainties of decommissioning are so great that we should do nothing at the present.[3] It has been further argued that the costs might eventually prove to be much lower than expected, and we might, therefore, needlessly collect more funds than necessary. Unfortunately, recent examples in the nuclear field as well as other new high-technology fields have shown that unknowns and uncertainties are often resolved at the expense of more regulation and higher costs. It would be imprudent to do nothing regarding decommissioning until all uncertainties are resolved, for these will, ultimately, only be resolved after a larger body of decommissioning experience has been accumulated. There are, however, modifications that can be made to financing mechanisms that can attempt to cope with whatever cost uncertainty exists.

Figure 4
SOME POSSIBLE FINANCING SCHEMES



The resolution of this apparent dilemma is fairly simple: annual reassessments of the future estimated costs, the future inflation rate, and/or the rate of return on invested monies and the remaining reactor life could all be factored into the financing mechanism to provide a readjustment of the amount of funds that would need to be accumulated that year. Such an "adjustable" financing mechanism would have the feature of "homing in" on the eventual decommissioning costs and, therefore, any mechanism adopted should have the ability to be periodically readjusted for changes in the estimated costs of decommissioning.

Summary of Criteria for Selecting Financing Mechanisms.

In summary, factors that should be considered in selecting a financing method should include:

- o Collection of all funds from the consumers of the reactor's electricity;
- o Maintenance of the funds in cash, negotiable securities, or other liquid assets to protect against future utility insolvency;
- o Provisions to ensure that the total decommissioning costs will be available at any time in case of premature shutdown; and
- o Ability to readjust the rate of accumulation to account for uncertainties in original cost estimates.

MECHANISMS FOR FINANCING DECOMMISSIONING

The discussion above focused on four criteria by which potential financing mechanisms may be evaluated and compared. A large number of potential schemes for accumulating decommissioning costs can be constructed from the possible combinations of financing features which attempt to deal with the four criteria. It would be extremely laborious to discuss and evaluate all possible combinations but a sample of representative and distinctive financing possibilities will be considered in this section. As displayed in Figure 3, there are several mechanisms, and these are discussed below in the following groups: (1) expensed, (2) funded, including lump sum funded account and sinking fund account, (3) depreciation account (straight line remaining life method), and (4) bonding including premature-shutdown insurance and surety bonds. Figure 4 demonstrates that a variety of mechanisms can be constructed that are of either the funded or depreciation account type.

(1) Expensing: Future Power Users Pay Decommissioning Costs. As argued above, whatever mechanism is adopted, it must be structured to obtain decommissioning funds to the greatest degree possible from the ratepayers during the operating life of the reactor. While it is theoretically possible that decommissioning costs could be expensed and paid at the time they are incurred (see Figure 3), such an approach would be inequitable given the substantial costs that would be borne by non-benefiting future ratepayers. Additionally, such a mechanism might increase the possibility of the state or other governmental body becoming financially responsible. The financing option of simply expensing and paying for decommissioning at the time of dismantling is, therefore, rejected as an inequitable alternative.

(2) Funded Mechanisms: Real Assets Accumulate to Pay for Decommissioning. Funded schemes are, for the purposes of this discussion, briefly defined to be those financing methods in which cash or negotiable assets readily convertible into cash such as stocks and bonds, are accumulated by the utility to pay the costs of decommissioning (see Figure 3). Such monies, collected from the ratepayers, are not available to the utility for their general operating needs and may be spent only for decommissioning.

The money accumulated by a funded-type mechanism could either (a) be held under the direct control of the utility, but as a separate account or fund, or (b) the monies could be turned over to a third party, such as a bank, to be held essentially as a trust fund. Such collected monies would not be allowed to sit idly but would be invested or otherwise put to work to earn interest or other income. This would enable the accumulated monies to keep pace with the inflating costs of decommissioning. If the rate of return earned by this invested money was greater than the inflation rate, the income from investment would also help the total worth of the fund increase and thereby decrease the amount of funds that future-year ratepayers would have to add. While there is some risk that some of the investments could lose value, the investments could, of course, be made in high-grade securities and spread over a diverse group of issues to minimize the potential for any loss.

The funds established either inside or outside the utility could be structured so that the rate at which monies are collected from ratepayers over the reactor's life could vary considerably. At one exteme would be the lump sum method (see Figure 3). Estimates are first made of the present costs of decommissioning, the inflation rate between now and the time of decommissioning, and the expected rate of return on invested income over the same period. The estimated future costs are then calculated, as well as the present amount of money that, when invested earning the estimated rate of return, will grow to equal the predicted cost at the expected time of decommissioning. This calculated amount of principal is then provided at the start of reactor operation and, if all estimates are correct, no future money need be extracted from the ratepayers.

In order to spread the contribution of funds over the entire reactor lifetime, a sinking fund could alternatively be established. Given the same information and predictions of inflation and investment return, calculations can be performed that will determine the amounts of money that ratepayers might pay on a yearly basis over the reactor life than when totaled, along with interest earned, would equal the anticipated final decommissioning costs. Sinking funds, as commonly calculated, require that the yearly additions to the principal of the fund by ratepayers will be equal over the expected reactor life. If inflation continues during the life of a reactor, it might be argued that the ratepayers in later years of reactor life will be making their contributions to the sinking fund in dollars that are inflated and, therefore, worth less than those contributed by ratepayers in the early years. It should be possible to calculate a sinking fund, however, that incorporates some inflation rate for the value of money. In this manner later-year ratepayers might make a larger dollar contribution to the fund but one whose constant dollar worth is close to that of earlier contributors.

Since either the lump sum or the sinking funds can be originally calculated for certain estimates of decommissioning cost inflation, investment return and reactor life, it might be possible to set these mechanisms in motion and leave them unchanged until the date of anticipated shutdown is reached. If, however, the estimates of the parameters of inflation, return, and lifetime are off, even by small amounts,the amount of funds accumulated and the time course of this accumulation may be substantially different from the eventual time and funds required. For this reason either of these funded mechanisms could be implemented in an "adjusted" manner to accommodate these uncertainties.

An adjusted fund, either lump sum or sinking, would be one in which periodic (yearly, for example) reassessments are made of present estimates of future inflation rates, rates of return, and remaining reactor life. Using the amount of funds accumulated at that point in time plus the above new estimates, the funds could be recalculated and new figures for the amount and schedule of additions to principal could be produced. As a result, an addition or reduction might be necessary in the principal contained in the lump sum fund or in the yearly installments of sinking fund. For either mechanism, periodic readjustments should guarantee that the funds accumulated will approximate the eventual amount required, barring some sudden and unexpected premature shutdowns.

That even an adjusted fund might be unable to accumulate sufficient monies in the event of premature shutdown may not be immediately obvious. Figure 5 graphically displays the rate at which funds would accumulate under a variety of mechanisms for one set of assumptions. The assumptions made are:

- o If the reactor in question were decommissioned immediately after construction, the cost would be $40 million at that time;
- o The expected reactor lifetime is 30 years;
- o The costs of decommissioning will inflate at five percent per year;
- o Money invested will return 10 percent tax free; and
- o Present tax laws applicable to utilities remain for the next 30 years.

Looking first at the line for decommissioning costs, one can see that the cost grows exponentially to a value of $172.8 million after 30 years, more than a four-fold increase. The lump sum fund under these assumptions would require $9.9 million in Year 0 to accumulate $172.8 million in principal and earnings in 30 years, while a sinking fund with equal yearly payments by the ratepayers would require the addition of $1.05 million per year to do the same.

For either fund, only within the last few years of reactor life do the accumulated monies come close to equaling the cost of decommissioning. If the reactor shuts down 15, 10, or even 5 years prematurely, the monies accumulated would be substantially deficient and non-benefiting ratepayers, utility shareholders, or the public would have to provide the difference. It is for this reason that consideration should be given to the addition of a bond to any fund; section (4) below discusses bonding.

(3) Depreciation Account: Decommissioning Funds Exist Only on Utility's Books. An alternative to setting aside funds or gradually accumulating funds for decomissioning is the depreciation account mechanism. Briefly, a utility, upon collection of monies for decommissioning from ratepayers but finding that the monies are not needed for 30 or more years, might decide to use these funds for the general operation of the company or the purchase of new equiment. While the actual money collected would be spent for non-decommissioning purposes, the utility would keep track on its books of the dollar amount of the accumulated depreciation. The transformation of this "accumulated depreciation" into cash to pay the costs of decommissioning would not occur until the actual work was performed and would be accomplished by using utility income at that future time.

One commonly employed form of depreciation assumes that the value of an object decreases linearly over the estimated remaining useful life of the item. This method of calculating depreciation is termed straight line remaining life (SLRL). In the case of a reactor, the operating utility estimates that over the anticipted life (usually 30 years), the value of the plant will decline to a worth less than zero. This results from the fact that when a reactor is no longer useful, it cannot simply be abandoned at no cost to the utility but must be decommissioned, requiring an additional expenditure of funds. As a result, its worth decreases not just to zero but actually crosses zero to become a negative amount symbolizing these decommissioning costs.

Using SLRL depreciation, a utility would claim that for a reactor with a 30-year life, one-thirtieth of the original construciton cost plus eventual decommissioning costs must be recovered each year from the ratepayers so that not only the original costs can be recovered, but also money for decommissioning will be available at shutdown.

In the case of the fund-type mechanisms previously discussed, the use made in the interim of money collected for eventual decommissioning was specific and restrictive. The incoming money would be kept separate from other utility income and invested to earn a rate of return in a manner which would permit ready conversion back into cash. For depreciation-type methods, the interim use of money collected during the reactor's operating life is not restricted. The money may be treated as ordinary income and used as such to pay any expenses the utility might have or to invest in capital improvements, such as new non-reactor facilities and equipment. The amount of the decommissioning money collected under these depreciation procedures would be entered on the company books in an account for "accumulated depreciation". Since the actual money collected from ratepayers was spent shortly after collection for non-decommissioning purposes, the payment of decommissioning expenses, when they are finally realized, would have to be made out of utility income at that time. An important component of the depreciation-type mechanism that deserves particular attention, therefore, is the expected ability of a utility to generate at the time of decommissioning income sufficient not only to meet normal operating needs at that time but also sufficient to meet the costs of decommissioning without burdening future ratepayers.

Depreciation-type mechanisms keep the accumulated decommissioning monies inside the utility--as opposed to the funded mechanisms, which might be set up either

within the utility or with outside agencies. Figure 4 shows that the depreciation approach can be of either the adjusted or nonadjusted variety. In a nonadjusted SLRL format, the estimated costs of decommissioning are simply divided by the years of remaining life and that amount is added to the depreciation account each year. Adjusted mechanisms, as with the funded approach, periodically reevaluate the magnitude of estimated costs and the expected remaining life. A new number may thereby be derived for the yearly amount depreciated for purposes of decommissioning. Nonadjusted depreciation methods suffer the same fault as nonadjusted funds: if the original guesses prove to be inaccurate, the funds eventually accumulated may differ substantially from the required amount.

Either adjusted or nonadjusted depreciation methods might in theory be established that use, as their basis for calculating the initial rate of asset accumulation, either the estimates of decommissioning costs at the present time or an estimate of costs at the future time of decommissioning. For a nonadjusted depreciation method, use of the estimated future costs is essential if the utility hopes to be even close to the eventual costs incurred. This results from the enormous increase in costs over 30 or more years for even low rates of annual inflation (see Figure 5). While an adjusted depreciation mechanism should, at least on paper, accumulate the proper amount of money by the time of expected reactor retirement, if the present cost is used as the basis for calculating depreciation at the start, the rate of accumulation will be slow until the last few years of reactor life. In this case the difference between accumulated money and decommissioning costs in the event of premature shutdown will be greater than if some estimate of inflated future costs were originally used as the basis for depreciation at the outset.

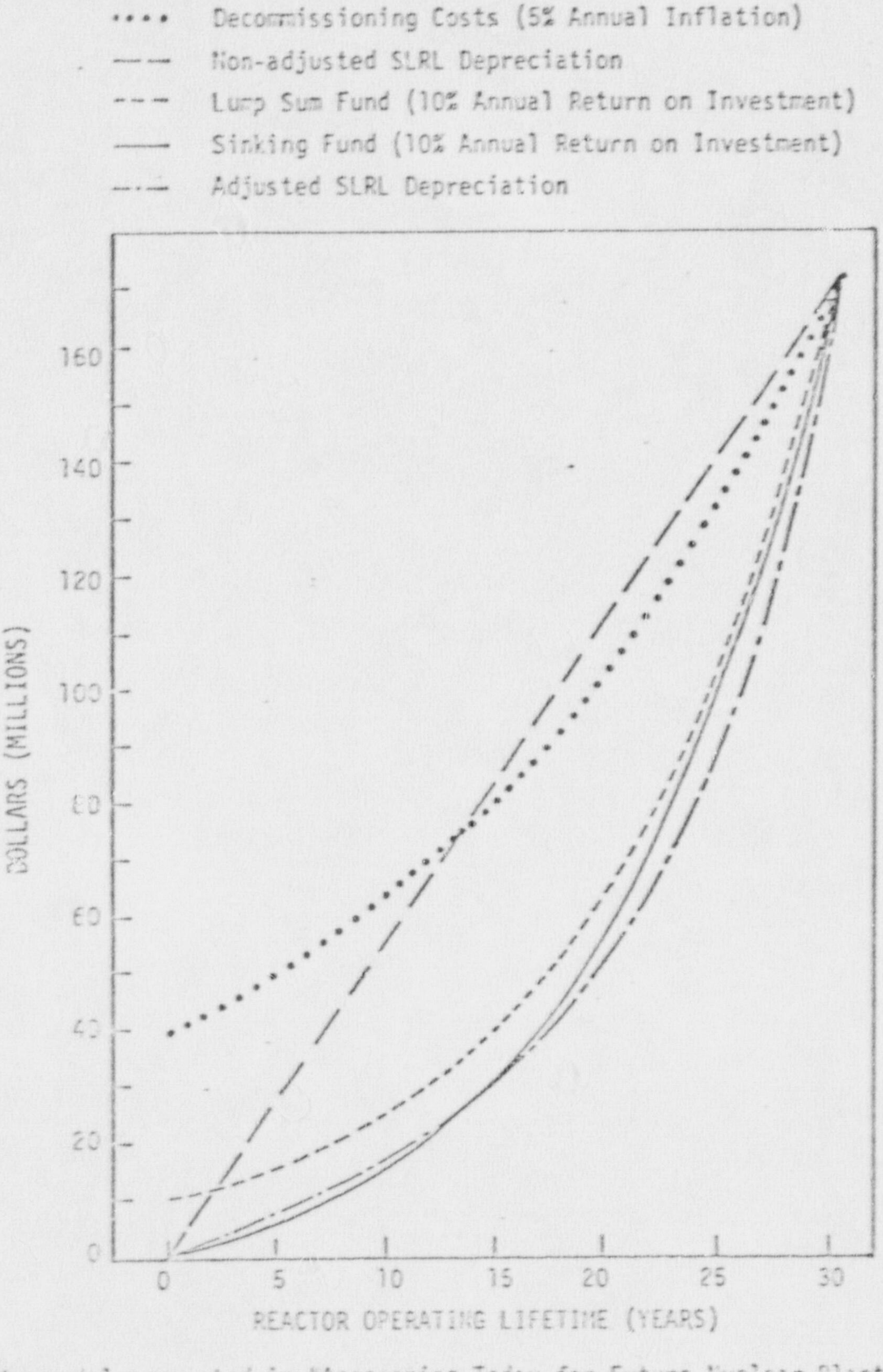
Just as with funded methods of providing for decommissioning, the depreciation methods are generally inadequate to handle the possibility of premature shutdown, especially if present costs are used as the initial basis for calculating depreciation. As a result, the depreciation approach might also be benefited by the addition of a performance bond or other mechanism to cover the deficit in the event of premature shutdown.

(4) Bonding: Insurance of Sufficiency of Funds to Pay for Decommissioning. The preceding discussion has focused on financing mechanisms in which all monies for decommissioning would be accumulated by the reactor operator. There is another approach to ensuring that in certain unusual circumstances, monies will not have to be extracted from the public or non-benefiting ratepayers and that is the use of a bond. While there might be many uses of bonding as components of a complete financing mechanism for reactor decommissioning,this report will focus on two.

Premature-Shutdown Insurance. As discussed previously, if the financing of decommissioning relied solely on the use of the funded or depreciation mechanisms it is likely that in the event the reactor is forced to shut down before the anticipated end of its normal life, insufficient monies would have been accumulated to cover the costs of premature decommissioning. With funded or depreciation mechanisms, the accumulated monies reach the full amount required only at the originally predicted date of shutdown (see Figure 5). Given the past and present experience in the commercial reactor industry, it is not unlikely that there may be instances in the future in which a reactor will

Figure 5

A COMPARISON OF THE RATE AT WHICH SEVERAL FINANCING MECHANISMS ACCUMULATE DECOMMISSIONING MONIES



Based on the model presented in "Accounting Today for Future Nuclear Plant Decommissioning Cost" by Benjamin J. Ewers, Jr., presented at A.G.A. - E.E.I. Accounting Conference, Dearborn, Michigan, May 1977.

be forced to shut down prematurely. One possible method to ensure that the public or non-benefitting ratepayers will not be asked to make up any deficiency in the needed funds would be to require that the reactor operator purchase a bond that would provide the money necessary to cover the deficit in this event.

Surety for Availability of Accumulated Decommissioning Monies. It was previously pointed out that depreciation-type financing mechanisms depend upon the income of the utility at the time of decommissioning to provide the monies to cover this expense, and that financial or economic difficulties might restrict the availability of such income. A bond might be obtained by the utility that would require the bonding institution to provide monies in an amount up to the amount collected previously by the utility from ratepayers for decommissioning under depreciation in the event that the financial position of the utility at the time decommissioning will not enable the utility to generate sufficient cash from income to equal the amount it had collected as depreciation. The coupling, therefore, of (a) a requirement to obtain a bond to cover the accumulated monies in the event of non-payment by the utility and (b) some kind of premature-shutdown insurance could provide increased assurance that no part of the ultimate costs will be borne by the public or post-shutdown ratepayers.

It would appear that this latter use of bonding has been recently adopted by the Connecticut Public Utilities Control Authority in their decision permitting Connecticut Light and Power to use a depreciation mechanism to provide for the eventual costs of mothballing Millstone I and II. Connecticut Light and Power was required to file annually with the Connecticut PUCA a corporate surety bond to ensure that monies collected by depreciation will be used for decommissioning.[4]

The use of bonds in the manner described above may not be that dissimilar to the bonding authority that seven states presently have to require bonding of the operators of state licensed non-reactor facilities handling radioactive materials to ensure the eventual decontamination of these facilities.[5] The State of Kentucky is considering the use of bonding to ensure that the operator of a low-level waste burial facility in that state will pay both the costs of decommissioning that facility and of its perpetual care to protect future public health.[6] The NRC presently requires bonding of new licensees who operate uranium mills to similarly guarantee that decommissioning these facilities will be funded by the licensee.[7]

Costs of Bonding. Further study of the concept of bonding will be required in order to better determine who might be potential suppliers of such decommissioning bonds, what the exact costs of such bonds might be, and the factors that will affect these costs. It may be possible that the utilities affected could construct a pooling arrangement for these bonds such as that which presently exists to provide liability insurance and indemnification for reactor operators.

COSTS OF THE FINANCING MECHANISMS

All mechanisms under certain circumstances will recover the total expense of decommissioning, but some mechanisms may better reduce the risk that parties other than the ratepayers consuming the electricity will pay in the event of

less than ideal circumstances. Estimating the total costs to the ratepayer and utility of possible funding mechanisms is a complex and arduous task.[8] Since the primary reason for implementing any special procedures for gathering monies for reactor decommissioning is to provide some level of assurance that the total costs will be borne by the appropriate parties, it seems more important at the present level of this review to concentrate on the benefits and disadvantages of different mechanisms rather than on the net costs to ratepayers of implementing different mechanisms. In this light, detailed discussion of the comparative costs of implementing various mechanisms will be deferred for future analysis. It is appropriate at the present time, however, to give some indication as to the number of factors than can influence the eventual implementation costs.

From the previous discussion of various financing mechanisms, it should be clear that two important factors in predicting the total costs of implementing any mechanism are the future inflation rates and the future rate of return on invested income. The estimated total costs of any mechanism involving a fund or a depreciation account are very sensitive to the predicted inflation rate since inflation compounded is a power function and one property of such a function is that the value at some future point can be drastically altered by small changes in the rate at which it increases (i.e., the inflation rate). As an example, 4 percent annual inflation rate over 30 years will produce a 224 percent increase in the original cost of an item. Doubling the rate to 8 percent per year does not simply double the 30-year increase to 448 percent but rather to 906 percent.

For funded procedures, such as the sinking fund or the lump sum fund, the expected rate of return from investing the accumulated principal is similarly sensitive since, if accumulated principal and interest are reinvested, the total accumulated funds will grow rapidly. If the original estimate of the amount of total funds that will result from interest or other income earned from investing the ratepayers contribution is even slightly inaccurate, the eventual amount that ratepayers must contribute to the fund, and therefore the total cost to ratepayers, may change dramatically.

In addition to these two factors, tax laws play a large part in determining the total costs to ratepayers. For mechanisms such as the depreciation account, present tax laws do not permit the utility to subtract the yearly funds set aside for decommissioning from that year's income. As a result income taxes must be paid on the money received from ratepayers for decommissioning. Since taxes are in theory almost half of income (48 percent) for utilities, almost $2 must be collected from ratepayers in order to have $1 after taxes to put aside for decommissioning.[9] The situation may be even more complex. The ratepayers may receive a credit based on the interest the utility would have had to have paid to go outside the company to borrow money equivalent to the collected decommissioning monies it was allowed to use. In addition, there may be future tax credits piled on top of this credit.

For a mechanism involving a fund, the total costs are affected by whether or not tax has to be paid on the interest earned from investing the collected principal. If investments are made in tax-free securities or if a special tax break were allowed this interest income, the effective rate of return would be altered. The California PUC staff has pointed out in a recent decommissioning

action regarding San Onofre 1 that, under present tax law, when decommissioning is actually performed the utility will have a large tax deductible expense and consequently will have a tax break that will benefit the utility's shareholders or its post-decommissioning ratepayers but not those ratepayers who actually paid the decommissioning costs.[10] Handling this tax break equitably will not be easy. The costs of a bond used to cover premature shutdown might also be difficult to predict since, if original predictions of the frequency of premature shutdown and the costs of decommissioning at those times prove inaccurate, the annual fees for the bonds will have to be adjusted just as would the annual premiums of an insurance policy.

CONCLUSIONS

1. When selecting a financing mechanism for decommissioning, care must be taken to ensure that the mechanism chosen is selected on the basis of why a mechanism is thought to be needed and what the mechanism is intended to ensure rather than solely or largely on the basis of how much the mechanism costs.

   Financing methods for reactor decommissioning are intended to be insurance devices ensuring that the appropriate parties will bear the costs whenever the need for this terminal disposition arises. As a result, it is important that decisions as to the need for and form of such a mechanism result from a determination of what amount and type of "insurance" is needed before consideration of its cost. The possible financing methods are clearly not equal in the extent and breadth of protection they afford.

2. Old financing solutions may not be appropriate for reactor decommissioning.

   It may not be prudent to automatically extend financing procedures that have previously been found useful for providing for disposal and replacement of certain other utility equipment to reactors. Because reactors concentrate very large sums of money in very few items and because of the relatively large negative salvage value and short history, procedures which may prove adequate for retiring, replacing and disposing of transformers and pick-up trucks need to be reevaluated before being applied to billion dollar nuclear reactors.

3. Reactor specific detailed decommissioning cost estimates should be obtained for each reactor before implementing any financing mechanism.

   Few cost estimates presently available appear to have been the result of a thorough evaluation of the costs of terminally disposing of a reactor. The costs are highly dependent on the degree and manner of decommissioning envisioned. Detailed, thorough cost estimates can be prepared at a relative small cost with the cooperation of the operating utility.

4. Efforts need to be undertaken immediately to resolve questions regarding the effect of taxation on costs of implementing various financing alternatives.

   The costs of employing the various financing alternatives discussed will vary depending upon the tax treatment monies accrued under these mechanisms received. Resolution or revision of state and federal tax policies could hopefully enable mechanisms which afford the greatest protection to the public and most equitable distribution of decommissioning costs to absorb the most inexpensive to the ratepayers paying for decommissioning.

5. Arrangements should be explored which would permit reactor operators to obtain surety bonds and premature shutdown insurance at the lowest cost.

Reactor operators presently use pooling arrangements to provide accident insurance. Similar pooling arrangements between reactor operators, private bonding organizations and/or state and federal agencies should be examined as a means to ensure that the surety bonds and premature shutdown bond discussed above will be available and at the lowest possible cost.

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