DOE/EIS-0015
VOLUME 4

FINAL
ENVIRONMENTAL IMPACT STATEMENT
U. S. SPENT FUEL POLICY

Charge for Spent Fuel Storage

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FOREWORD

Spent fuel removed from a nuclear power reactor contains unfissioned nuclear fuel together with radioactive waste. On April 7, 1977, President Carter announced that the United States would indefinitely defer reprocessing of spent fuel for recovery of the unfissioned fuel while the U.S. and other countries evaluate alternative fuel cycles and processes which may reduce risks of nuclear weapons proliferation. Eventually the spent fuel will either be declared to be entirely waste and provisions made for its disposal, or it will be reprocessed to separate the wastes from the unfissioned nuclear fuel which may then be recycled and the waste disposed of separately. However, pending future decisions as to its ultimate disposition, the spent fuel discharged from U.S. power reactors must be stored, protected, and safeguarded.

In October 1977, a presidential policy on the interim management of spent fuel was announced. Under this policy, the Federal Government would offer to take title to and provide interim storage for spent fuel from U.S. power reactors. The analysis of impacts associated with alternatives with respect to implementation of this domestic Spent Fuel Storage Policy, is being issued as Volume 2 of this Environmental Impact Statement (EIS).

In addition, under this policy, the Federal Government would offer to take title to and accept a limited amount of spent fuel from foreign sources, when such action would contribute to meeting U.S. nonproliferation goals.

Alternatives regarding implementation of this foreign portion of the policy are analyzed in Volume 3 of this EIS.

Another aspect of the announced policy is that the Federal Government will charge a fee to fully recover all the Government's costs for spent fuel storage and disposal. This Volume has been prepared to provide environmental input into decisions on alternative fee methodologies. As such, it addresses the effect, if any, of these methodologies on the growth of nuclear power and on the degree of projected participation by domestic utilities and foreign countries in the proposed spent fuel storage programs.

13-a It is not the purpose of this EIS to develop the specific dollar fees which will
13-o be assessed as the U.S. Spent Fuel Policy is implemented. However, it is necessary to use reference fee levels (and perturbations from this reference) to evaluate possible environmental effects of the fee. For this purpose the cost basis developed by DOE in their preliminary estimates* has been used and material and cash flows described in this report are for illustrative purposes only.

DOE's preferred action is that the Spent Fuel Policy announced in October
1-a 1977 be implemented. The proposed action is to charge a fee for acceptance of spent fuel for storage and/or disposal that will recover to the Government the full cost of providing the services. These costs will be assessed appropriately for the combined storage and disposal services or for disposal services only, as required by individual customers (that is, the fee will be "Use-Based"). The fee will be identical for all fuel, regardless of country of origin.

*Reference 5, Page I-10.

A detailed analysis of the environmental impacts associated with disposal of spent fuel is contained in the EIS for commercial waste management which has been issued in draft form as DOE/EIS-0046-D.

A Glossary of Terms and Abbreviations is included as Appendix B.

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I. SUMMARY AND CONCLUSIONS

A. Background

The United States Government policy relating to nuclear fuel reprocessing, which was announced by President Carter on April 7, 1977, provides for an indefinite deferral of reprocessing, and thus commits light water reactor (LWR) plants to a once-through fuel cycle during that indefinite period. In a subsequent action implementing that policy, the Department of Energy (DOE) on October 18, 1977[1] announced a spent fuel policy which would enable domestic, and on a selective basis, foreign utilities to deliver spent fuel to the U.S. Government for interim storage and final geologic disposal, and pay the Government a fee for such services.

This volume addresses itself to whether the fee charged for these services, by its level or its structure would have any effect on the environmental impacts of implementing the Spent Fuel Policy itself. This volume thus analyzes the fee and various alternatives to determine the interaction between the fee and the degree of participation by domestic utilities and foreign countries in the proposed spent fuel program for implementing the Spent Fuel Policy. It also analyzes the effect, if any, of the fee on the growth of nuclear power.

The options open to the U.S. Government in this area include:

1) Implementation or non-implementation of the Spent Fuel Policy; and assuming implementation,

2) Establishment of a fee based on full-cost-recovery or, alternatively, a fee subsidizing either the customer or the Government.

3) Collection of the fee either at time of transfer of fuel to the Government or, alternatively, at an earlier or later date;

4) Payment of the fee on either a one-time or non-one-time basis;

5) Establishment of a fee related to services utilized (use-based) or, alternatively, a single fee for spent fuel acceptance by the Government ("levelized");

6) Accrual and disbursement of funds through the DOE budget process, through a separate trust fund or directly through the Treasury.

7) Establishment of a fee based upon equal charges for either foreign or domestic fuel and alternatives to this option.

B. General Conclusions

1. Environmental Impact: Volumes 2 and 3 of this EIS on the U.S. Spent Fuel Policy analyzed the environmental impacts of options with respect to the implementation of the October 1977 policy announced by DOE. The summary conclusion regarding storage of domestic fuel from the Executive Summary (p.18) is relevant in providing perspective: "The environmental impacts from all alternatives considered either from implementing or not implementing the spent fuel storage policy are nominal (and) the impacts are relatively small compared with available resources and risks from natural radiation sources."

Within the context of relatively small overall environmental impacts, there are storage alternatives which might evolve and which could be influenced by the fee structure. One alternative assumes maximum expansion of reactor discharge basin storage capacity and use of small Government or privately operated Independent Spent Fuel Storage (ISFS) capacity as required and is consistent with the reference fee evaluated. The other alternative assumes major storage of spent fuel at one or more large ISFS facilities and could be fostered by establishment of a "levelized" fee. Other fee variations evaluated encourage evolution of one or the other of these storage modes. The basic environmental impact difference between these storage alternatives is related to the increased transportation and fuel handling requirements which might result from the "levelized" fee compared to those due to the reference fee. The major environmental effects of these alternatives are shown in Table I-1 Cases B&C. The effects related to storing fuel in newly constructed at reactor-basins (ARB's) are also included in this table to illustrate that the environmental advantages due to increasing onsite storage are outweighed by construction, operation and decommissioning effects when new facilities are required. Because individual utility decisions on spent fuel management options are based not only on economic issues but also on such issues as physical limitations of onsite facilities, timing of additional capacity needed, company cash flow considerations and company operating philosophy on the amount of reserve storage capacity required onsite (among others), these comparisons must be viewed as indicative of fee effects rather than definitive.

2. Impact of the Fee Structure on the Growth of Nuclear Power: Within the range of the fee level examined in this analysis, which is believed to cover all reasonable expectations, the cost of the waste management portion of the fuel cycle would vary from 0.23 to 0.48 mills/kWh or about 1-2% of total generation costs.

It thus appears that even at the upper end of the range of fees examined, the spent fuel and waste management policy would not impact the economics of nuclear power significantly enough to change importantly the[2] economic comparisons between nuclear power and coal in most regions of the U.S.

1-a 3. Proposed Action: DOE proposes that the Spent Fuel Policy announced in October 1977 be implemented. The proposed action is to charge a fee for acceptance of spent fuel for storage and/or disposal sufficient to recover to the Government the full cost of providing the services. These costs will be assessed appropriately for the combined storage and disposal services or for disposal services only, as required by individual customers (that is, the fee will be "Use-Based"). The fee will be identical for all fuel, regardless of country of origin. The

TABLE I-1

Major Fee-Related Environmental Effects[(a)]

	Case A Non-Implementation of Spent Fuel Policy (At-Reactor Basin Storage)		Case B Implementation of Spent Fuel Policy "Use-Based" Fee		Case C Implementation of Spent Fuel Policy "Levelized" Fee	
	Domestic[b] Fuel	Foreign[c] Fuel	Domestic[d] Fuel	Foreign[e] Fuel	Domestic[f] Fuel	Foreign[e] Fuel
Effects						
Energy						
Propane, m^3	7.7×10^3	0	1.7×10^2	3.3×10^2	5.9×10^2	3.3×10^2
Diesel Fuel, m^3	3.1×10^5	0	1.7×10^5	2.7×10^5	1.7×10^5	2.7×10^5
Gasoline, m^3	1.4×10^5	0	3.0×10^3	4.6×10^3	1.0×10^4	4.6×10^3
Electricity, MW-yr	1.8×10^2	0	8.2×10^0	8.9×10^1	6.5×10^1	8.9×10
Coal, tonne	1.2×10^6	0	5.4×10^4	3.4×10^5	4.0×10^5	3.4×10^5
Man-power, man-hour	1.1×10^8	0	3.9×10^7	1.1×10^7	4.5×10^7	1.1×10^7
Radiation Dose Commitment, man-rem						
Population[g]	4×10^3	5.5×10^3	3×10^2	8.5×10^2	1×10^3	8.5×10^2
Work Force	6×10^3	0	8×10^2	7.1×10^2	1×10^3	7.1×10^2
Health Effects[h]						
Population	2	N.A.	1	N.A.	1	N.A.
Work Force	4	N.A.	1	N.A.	1	N.A.
Total	6	3.2	2	1.0	2	1.0
Occupational Accidents (Nonradiological Fatalities)	23	0	11	3.4	11	3.4

N.A.-not available

a. Summary of major environmental effects of storage and disposal of spent fuel amounts affected by the fee structure. Reference (use-based) fee and levelized fee. Non-implementation of spent fuel policy is included for comparison. Disposal of spent fuel is assumed to commence in 1985. See Table IV-3 for details.

b. Case A (domestic fuel) is equivalent to Alternate 2B in the EIS in storage of domestic fuel (Volume 2).

c. Case A (foreign fuel) is equivalent to Case A in the EIS in storage of foreign fuel (Volume 3). The population effects listed are for U.S. and Global Commons.

d. Case B (domestic fuel) is equivalent to Alternate 1B-2 in the EIS on storage of domestic fuel (Volume 2).

e. Cases B and C (foreign fuel) are equivalent to Case D in the EIS in storage of foreign fuel (Volume 3). The population and work force effects listed are for U.S. and Global Commons.

f. Case C (domestic fuel) is equivalent to Alternative 1B-1 in the EIS on storage of domestic fuel (Volume 2).

g. Whole body dose during the operating period plus the next 100 years. For comparison, the equivalent dose to the world population from natural radiation sources over the same period is 2×10^{11} man-rem. This natural dose will result in 120 million health effects.

h. Serious genetic and somatic health effects were calculated from radiation doses assuming a linear dose-health effect relation. EPA dose-effect factors were used.

c proposed action deals with Options 1, 2, 5 and 7 of I.A. above.

Details such as payment schedule and funding mechanisms will be developed
13-s as the program proceeds and specific contracting procedures are developed; therefore no action is yet proposed regarding Options 3,4 and 6 of that section.

3. <u>The Logic of Maximum Compaction (Expanded Reactor Discharge Basin Storage):</u> Maximum compaction by using nuclear poison racks in existing reactor discharge basins, enables the utility to take advantage of existing auxiliary equipment, site preparation and licensing work, all of which would have to be supported separately in a newly constructed ISFS. In addition, fuel that can be stored on-site prior to ultimate disposal will require transport only once, rather than twice (from reactor to ISFS and from ISFS to Spent Fuel Repository (SFR). On economic grounds there appear to be substantial benefits from maximum expansion of utilities' on-site
11-a basins. As discussed in Item (1) above, it is recognized that economic
13-m considerations are only one factor in determining the amount of fuel that can be accommodated in an existing reactor discharge basin. Regulatory requirements and related timing of availability of storage capacity will also affect the amount of spent fuel thus stored.

4. <u>The Possibility of Future Reprocessing;</u> It is the implicit assumption of the
c proposed fee structure that spent fuel is herein treated as a nuclear waste. The fee structure does not consider any explicit provisions for subsequent change in government policy reinstituting the reprocessing of spent fuel and recycle of residual values. Such a change in government policy would be accomplished in conformance with NEPA requirements. At the time any such change in policy is made, and the appropriate NEPA processes, enabling legislation and other institutional processes as necessary are followed, questions that must be addressed include: (i) whether existing fuel in storage would be retrieved or whether the revised policy would apply only to new fuel; (ii) what the cost of such retrieval would be if the former course is elected; (iii) what impact the change in policy would have on the unamortized portion of the then existing ISFS or repositories; and (iv) the costs of reprocessing and recycle and the economic advantage to the utility they would represent in light of then-known costs (the residual value function). No attempt has been made to estimate these uncertainties and to build in to the current fee structure any speculative provisions for what the future may bring in this regard.

C. <u>Summary of the Analytic Approach</u>

The services for which costs must be recovered in the proposed fee are interim storage in an Independent Spent Fuel Storage Facility (ISFS) followed by disposal in
c a Spent Fuel Repository (SFR) or alternatively, disposal only. A number of alternate fee structures have been analyzed to determine if they have a bearing on the environmental effects of the implementation of the Spent Fuel Policy as well as to consider their feasibility, desirability and acceptability by all of the parties concerned. Different fuel flows were used in establishing the fee and evaluating
13-w the environmental effects to provide a conservative assessment in each case. A lower estimate of fuel flows was used to establish fee parameters to give the maximum economic effect. A higher estimate of fuel flows was used to determine the environmental effects. The key elements of the proposed fee structure in this analysis are:

- Type of Fee
- c Equal Charges for Domestic and Foreign Spent Fuel
- The Level of the Fee

c o Perturbations
- o Fee Payment Schedule
- o Cost Computation Methodology

1. Type of Fee: There are several alternative philosophies as to the type of charge to be assessed for the users of the spent fuel management services being provided by the government. As is discussed in detail in the body of the analysis (Section II), there is substantial precedent for considering that inasmuch as the service is of benefit to specific customers, those customers should be charged a fee representing recovery of full cost to the government.[3] If the service is considered to be more broadly in the national interest, e.g., non-proliferation objectives, the government can elect to absorb certain costs, e.g., compensate for the restrictions placed on use of private property to further a national objective. There have also been precedents for penalty pricing, e.g., attempts to impose "commercial pricing" for enrichment services, where the government can charge a fee which goes beyond recovery of its costs.

Of concern in this EIS evaluation is how or whether the level of the fee established by these three different pricing philosophies would have an environmental impact. (Other than with respect to the growth of nuclear power it should be noted that any impact with respect to domestic spent fuel would be limited to the storage phase where the user utilities may either ship to a government ISFS, or expand on-site storage, or private ISFS storage capacity. Under current policy, domestic utilities have no options for disposal of spent fuel except to take the government service at whatever price the government selects.) The general effect of a fee significantly higher than the reference case would be to encourage maximum at-reactor-storage. Conversely, a fee significantly lower than the reference case (perhaps to the extent of paying utilities to result in power costs comparable to those in a recycle mode) would encourage more extensive transfer of spent fuel to the Government at an earlier date. The environmental impact of these alternative fee bases has effectively been represented in the analysis of the two storage alternatives.

2. "Use-Based" Fee Structure: There are fundamentally two services offered in the policy, namely, storage and disposal. The reference fee structure assumes a "use-based" or dual cost center pricing philosophy in which those utilities requiring both storage and disposal will pay a single fee for both of those services together, while those requiring only disposal (having suitable storage independent of the Government facilities) would pay for disposal only.

An alternative pricing structure would be a fee reflective of recovery of the total cost of both storage and disposal services to be paid by all utilities even though some require disposal services only. With this pricing structure, utilities would not be motivated to make any additional at-reactor-storage-capacity available as such modifications would represent an additional investment over and above the payments they would be required to make for storage by the government at the ISFS.

The "use-based" fee structure is also readily adaptable to changes in services which could be considered. For example, because of the timing and ability to cost the required future facilities and operations the single fee for storage and disposal could be changed to a fee for storage to be followed at some future time with a fee
13-a for disposal. Fuel flows arising due to such a change in structure - and related environmental impacts - would fall within the range analyzed in this EIS.

3. Equal Charges For Domestic and Foreign Spent Fuel: This document for
purposes of establishing a reference case for cost development assumes the fee
13-c structure adopted would apply equally to either foreign or domestic fuel.[4] Each
13-j customer is assumed to bear the costs of services of which he avails himself - that
13-r is, costs due to foreign fuel are borne by foreign users not domestic customers.
13-u The amount of foreign fuel transferred for storage and/or disposal in the U.S. is
12-p relatively insensitive to the fee, being determined more by individual national fuel
cycle plans and non-proliferation considerations.

4. The Level of the Fee: The purpose of this document is to examine the environmental impact of alternative methods of establishing the fee, as well as the impact of its structure and level. However, for analytic purposes, a "reference case" has been established in constant 1978 dollars embodying the above basic fee structural principles. In order to establish this reference case, spent fuel flows were assumed from both domestic and foreign utilities. The domestic flow used the so-called "reference" case of DOE's Preliminary Charge Estimate Document[5]. The foreign fuel flows utilized the minimum amounts evaluated in Volume 3 of this EIS, a level chosen in the interest of conservatism, since the lowest flow produces the highest costs.

In total, the flows used to develop the reference fee are about 3550 metric
13-w tons for storage and disposal through 1987 and approximately 55,000 metric tons for
disposal only from 1988 through the year 2000. In this reference case the assumption is made that the repository would be ready to receive spent fuel in 1988. It is recognized that this is the earliest date cited in the Interagency Review Group (IRG) report; perturbation analysis, however, includes the effect of a later start of the repository.

As noted in Table I-2, the figures stated are in constant 1978 dollars, not allowing for the effects of escalation. Escalation effects can be illustrated in the following example: At an assumed average escalation rate of 5 1/2%/year between 1978 and 1986, the fee in the reference case above, would increase from $202/KgU
c to $299/KgU for storage and disposal and from $114/KgU to $175/KgU for disposal
only.

5. Perturbations: It is assumed that a fee level would be set at the time utilities commit for the service. Presumably this would be some time before the deliveries to the government would actually be made. At that early stage, which would likely be before the facilities had actually been constructed, the fee would reflect a "best estimate"; thus, it is reasonable to consider perturbations around the reference case. It is intended that the fee would be reviewed periodically as the program implementation proceeds and, if required, based upon later and better knowledge, adjustments would be made. Depending upon the procedures decided upon and the circumstances as they exist at the time, these adjustments could either be applied to future customers alone, or in addition, retroactively to existing commitments. However, on this latter point, it should be noted that in the main, both the existing commitments and the future customers represent the same universe of utility organizations, and these circumstances should minimize any inequities in the actual procedures for making adjustments.

A number of variations from the reference case assumptions have been considered and are discussed in the text. These are intended to cover the most reasonable probabilities for cost change and thus to bracket the fee computed for

TABLE I-2

Reference Case* - Domestic and Foreign Fuel

	Dollars/KgU in 1978 Dollars	
	DISPOSAL ONLY	STORAGE AND DISPOSAL
ISFS	-	89
Transportation	-	24
Encapsulation	33	23
Geologic Repository	50	35
R&D and Government Overhead	31	31
TOTAL	114	202

*This case differs from that developed in Reference 5 because of the addition of 2160 MTU of fuel from foreign sources (Cumulative through year 2000).

the above-mentioned reference case. The resultant fee range is from $127-271/kgU for storage and disposal, and from $83-160/kgU for disposal only, both in 1978 dollars.

6. Fee Payment Schedule: The total cost to the U.S. Government consists of several categories of cost:

Capital Investment in the Facility
Operation and Maintenance Charges
Decommissioning Costs
Post Operation Surveillance Charges
Research and Development
Government Overhead
Carrying Charges

All of these costs except for the last item, carrying charges, are specific dollar investment items that relate to, and are amortized and recovered on a unit of production basis. The last item, the carrying charges, is not related to the units of production but is, in fact, dependent upon the schedule of the investment by the U.S. Government. Thus, early or pre-payment reduces this component of the fee to the government, and conversely later payments increase this component. On the other hand, the impact on the utilities is reversed, and since, in general, their money costs are greater than those of the U.S. Government, early payment impacts adversely on the rate payer.

In developing the cost of service it is assumed that any investment by the U.S. Government not covered by fee payments already received, accrues interest, at the Government rate, and is subsequently recovered in the fee. Conversely, if early payments are made by the utilities, accumulating a surplus compared to the expenditure schedule, such payments would also accrue interest to the benefit of the utilities, and would be reflected in a reduced fee payment.

With this procedure, the U.S. Government is effectively indifferent to the fee payment schedule as both the direct costs and the cost of money (interest) are covered by the fee. Any number of payment schedule variations including advance payments, partial advanced payments, and payment on delivery are possible. The final schedule adopted will reflect the weight given to such competing objectives as minimizing overall impact to the customer and minimizing U.S. Government investment.

As noted earlier, the utilities' view of the fee payment schedule is quite different from that of the U.S. Government. The cost as allocated to the fuel cycle varies substantially depending on whether there is prepayment or post-payment of the fee. The standard fuel accrual procedure is to collect the monies from the customers for any direct charges, such as the fee, during the period when the fuel is generating power. Federal Energy Regulatory Commission (FERC) accounting procedures which are commonly used in the ratemaking proceedings are such that prepayment to the U.S. Government would increase the nuclear fuel cost allocation as a result of prepayment being treated as a capital investment in the fuel cycle. Conversely, a late payment, e.g., on delivery, decreases the fuel cycle allocation because there is less of a fuel cycle investment. Also, inasmuch as the fee would be collected during the power generation period, substantive changes in that fee later, after the fuel has been discharged, represent an issue to be resolved with the individual state regulatory agencies.

Finally, one of the advantages of a later payment, e.g., on delivery of the fuel five years after discharge from the reactor, is that the cost of services at that time is better known, and therefore the fee can be more precisely reflective of the costs. If advance outlays by the government are to be minimized, some down payment on the fee, presumably at the time of contract and thus perhaps five years prior to shipment of spent fuel to the government, could be built into the contractual arrangement. Such an early payment of the fee would, since it would necessarily reflect an earlier stage of estimating, be subject to greater uncertainty and more likelihood of the need for later adjustment.

7. Cost Computation Methodology: The technique used herein to develop the fee value on a full cost recovery basis is to calculate the total expected costs, develop a cash flow pattern for these, impute interest based on the expected schedule for outlays of capital funds to implement the program, and then having developed the cash flow pattern, use present worthing or discounting techniques to properly account for the time value of the costs as they occur. This technique brings the total cost back to 1978 dollars, and develops a single, present worth value of the total cost. The discount rate used in such present worthing technique is taken herein to be 6.5%/year as representative of a long term average government cost of money.

A similar technique is then used to project the present worth of the future revenues to be collected. The future fuel deliveries to the government from utilities are estimated using the data as developed in the Charge Estimate document and Volumes 2 and 3 of this EIS. Using a similar discounting technique, a single present worth value of the fee can be computed such that the revenues to be collected over the period of time the service is rendered would equal the total cost to be expended by the U.S. Government to render that service.

From a cost methodology standpoint, as long as the discount rate is the same, as has been assumed herein, the procedure is essentially indifferent to whether outlays come from the general Treasury as required, or some separate special Department of Energy fund, or whether advance payments are collected and placed in some escrow account specifically designated for these purposes. However, if the cost of money to the U.S. Government would be different for such alternate possibilities for accruing and disbursing the funds, effectively changing the discount rate, the computation would have to take that into account.

References for Section I

1. DOE Announces New Spent Nuclear Fuel Policy -Press Release, U.S. Department of Energy, Washington, DC, (October 18, 1977).

2. Energy Information Administration Annnual Report to Congress, Volume II, DOE/EIS-0036-2, U.S. Department of Energy, Washington, DC, 1977.

c 3. Report to the President by the Interagency Review Group on Nuclear Waste Management, TID-29442, Washington, DC p. 121, (March 1979.)

4. Draft Report of Task Force for Review of Nuclear Waste Management, U.S. Department of Energy, DOE/ER-004/D, Washington, DC, (February 1978), p. 63.

5. Preliminary Estimates of the Charge for Spent Fuel Storage and Disposal Services, U.S. Department of Energy, DOE/ET-0055, Washington, DC, (July 1978).

II. COSTING DEVELOPMENT

A. Pricing Policy

A.1 Government Pricing Philosophy

In developing a pricing basis a number of factors must be considered. The configuration of the fee should be compatible with the user's requirements and also should be structured to optimize the overall costing of the system for the benefit of the total society. Further, there is a question of timing on the charges which clearly is important to the cash flow of both the supplier and user of the service. Finally, all of these functions must be put into a methodology which develops the fee structure and can cope with changes both environmental and economic during the total course of the time frame when the service is being provided. All of these considerations are subsequently reviewed in this costing development section.

Given the nature of nuclear waste and the potential for long-lived hazards in certain categories of waste (e.g., high-level waste), it is desirable that the institution having responsibility for such management and control be as "long-lived" as possible. It is clear, therefore, that Government or a Government entity similiar to the Federal Authorities such as Tennessee Valley Authority and not a single, privately operated corporation or other entity, should provide the services necessary for the final handling and disposal of high-level radioactive waste. It has generally been assumed that spent nuclear fuel assemblies, if sent for disposal, would be considered a high-level radioactive waste.

The alternate pricing philosophies for a charge for a U.S. Government service such as storage and disposal of spent fuel are:

1. Full Cost Recovery
2. Penalty Pricing
3. Commercial Pricing
4. Subsidy

A.1.1 Background to Government Cost Recovery

The movement in Congress in the 1950s to encourage U.S. Government agencies to establish fees to recover some of the costs of providing services resulted in enactment of the Independent Offices Appropriations Act of 1952 (IOAA)[1] which provides, in the pertinent part:

> "It is the sense of the Congress that any work, service, publication, report, document, benefit, privilege, authority, use, franchise, license, permit, certification, registration, or similar thing of value or utility performed, furnished, provided, granted, prepared, or issued by any Federal agency...to or for any person...shall be self-sustaining to the full extent possible, and the head of each Federal agency is authorized by regulation..to prescribe therefore such fee,

charge, or price, if any, as he shall determine...to be fair and equitable taking into consideration direct and indirect cost to the Government, value to the recipient, public policy or interest served, and other pertinent facts..."

It has generally been interpreted that where a service (or privilege) provides special benefits to an identifiable recipient above and beyond those which accrue to the public at large, a charge should be imposed to recover the full cost to the Federal Government of handling that service. However, no charge should be made for services when the identification of the ultimate beneficiary is obscure and the service can be primarily considered as benefiting broadly the general public.

Moreover, an "identifiable recipient" does not describe members of an industry which neither ask for nor receive a specific unit of service. It refers only to the applicant who derives a special benefit. Charges by a federal agency cannot be geared to penalty pricing without specific taxing legislation enacted by Congress and may not be factored into the agency's costs.

Under the mandated full cost recovery policy encompassed by IOAA, 31 U.S.C. 483a, a full cost recovery basis for spent fuel storage and disposal is clearly a service to the particular utility receiving that service and therefore the charge or fee is appropriate. One of the criteria to be followed is that the cost basis for each charge be assessed against the particular applicant receiving the service. To accomplish this step involves an allocation of specific expenses which form the cost basis of each charge to the smallest practical unit. (This particular point will be addressed later on in the development of a single charge for storage and disposal, or storage alone, versus a use-based charge which has two charges--the first for storage and disposal and the second, or alternative, for disposal alone.) Indirect charges can apply to the development of such costs, if such indirect charges are justified and directly related to the provision of such service. The indirect charges should apply to the special benefits gained by the applicant and not to those which accrue to the public at large.

It is important to note there is no requirement that the charges assessed represent the exact cost of the services to the agency. To be valid the fee need only bear a reasonable relationship to the cost of the services rendered by the agency. If the charges bear no reasonable relationship to agency costs (e.g., there is profit factored in, etc.), those charges cannot be assessed. There is no room in this calculation of full cost recovery for higher or lower charges based on criteria which assess economic benefit to the industry from public confidence in overall regulation, stability, health, welfare, etc. Any such subsidies or additional assessments would require specific legislation.

The Department of Energy has indicated that it will seek specific enabling legislation prior to constructing an Independent Spent Fuel Storage Installation and accepting spent fuel from customers (domestic or foreign) for storage and/or disposal. Authorization for a pricing system based on other than full cost recovery could be included in such legislation if it were determined that such a system would be desirable. The anticipated environmental effects of alternative pricing structures which vary the fee level are analyzed in Sections II A.2.2, III C and IV A.

Finally, different methods of obtaining full recovery of its costs may be adopted by the Government since it does not have to recoup these costs immediately but merely "over a reasonable period of time." There is no specific guideline as to what, under the circumstances, constitutes a reasonable period of time. However, a levelizing costing procedure using conventional business techniques, such as a discounted cash flow analysis over projected useful lifetimes of facilities, would seem to be reasonable. The reference methodology that satisfies this costing requirement is developed in Section II.C and Appendix A.

A.1.2 Liability Considerations

The transfer of spent fuel to the U.S. Government will result in the transfer of liability for damages to persons and property arising out of the handling, transportation, storage and disposal of such fuel to the U.S. Government or its contractors. The charge will be structured to include a factor to recover the potential costs to the U.S. Government of paying liability claims which may arise.

Depending upon the factual and contractual situations which may arise, the fee would be calculated to include insurance premiums U.S. Government contractors might pay plus a factor designed to compensate the U.S. Government for such sums it might be required to pay as an indemnitor pursuant to the Price-Anderson Act or as a self-insuror. This factor would be adjusted in the future as warrranted by experience gained in implementing the Spent Fuel Program.

A.1.3 Timing Operations

The timing of the payment of the fee does not directly bear on the question of full cost recovery as any payment time can meet that requirement. In a general sense it is clear that the later the payment the more correct the payment will be in matching the U.S. Government's costs for storage and disposal. Conversely, the earlier the payment the less that will be known about actual costs and hence whether a fee adjustment would be required at a later date or whether later fuel would have a changed fee schedule.

The economic effects of the payment time are clearly viewed differently by the U.S. Government and utilities. An earlier payment time gives the U.S. Government working capital for investment and operations and, hence, an apparently lower charge since there will be less capital appropriations which must bear a cost of money component to meet a full cost recovery principle. The utilities, on the other hand, relate the payment of the fee to a nuclear fuel cycle charge which is collected during the electrical generation period of a specific batch of fuel. A subsequent added charge, due because of an incorrectness of an early prepayment, creates some backbilling problem on the electric consumer. The utility view of the fee is generically covered in Section II.A.2 and quantitatively evaluated in Section III.C.

A.2 Fee re Total Electric Costs

c The extent and timing of participation in the U.S. Government Spent Fuel Program will be affected by the impact of the fee on total power generation costs. This section describes the methods used to evaluate the fee in terms of the fuel cycle cost incurred by the utility. The incremental fuel cycle cost incurred due to the fee is then compared to overall cost uncertainties faced by the utilities for both coal and nuclear units to enable discussion of the influence of the fee on the decision to build a particular type of facility. Conclusions can then be drawn regarding the potential fee-related environmental impacts of such a decision.

A.2.1 Fuel Cycle Cost Development

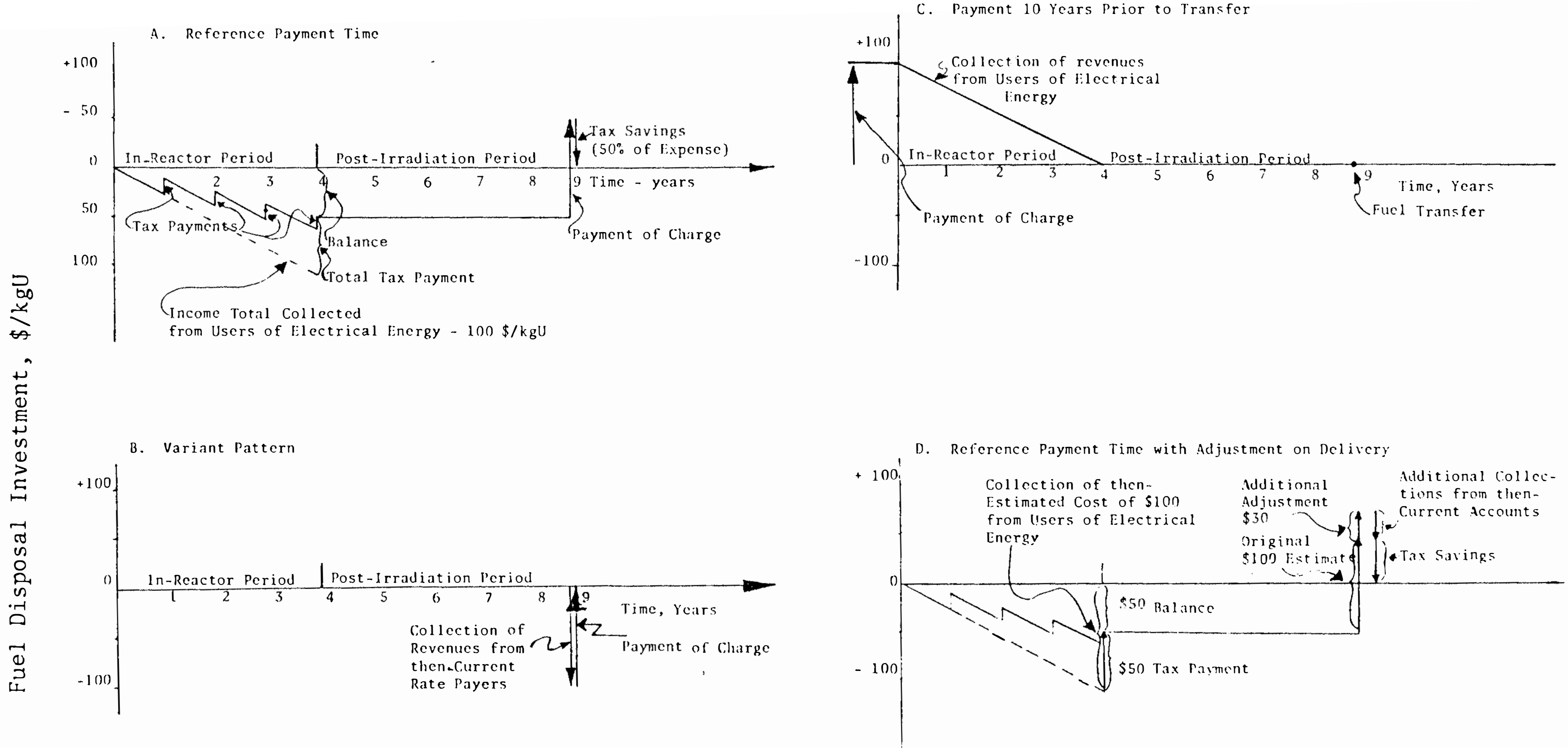
An important consideration in evaluating the impact that the charge methodology would have on the environment could be its effect on nuclear fuel cycle costs and consequently the utilities' decision to elect for a nuclear project as opposed to alternative generating capacity. As will be illustrated below a charge based on "full cost recovery" which might range from $150 to $250/kgU has a very modest impact on the cost of electric power generation from a nuclear power facility; consequently the level of the fee itself has little effect. The environmental analysis of a multiple cost center based fee for different scopes of service is found in Section IV.

The Federal Energy Regulatory Commission (FERC) has established typical guidelines for nuclear fuel accounting in its Uniform System of Accounts. These guidelines are used in reporting data to the Federal Government and are generally used by the State authorities in the development of an approved rate structure. The ultimate responsibility and authority for defining fuel cost accounting practices, at least for regulated utilities, rests with state and local regulatory bodies, which have exercised this right with some variations. Although these regulations apply only to the investor-owned utilities and not to utility authorities or to publicly owned utilities, it is generally true that the other utilities follow quite similar accounting practices modified appropriately to their financial structure.

Thus, the typical nuclear fuel accounting procedure can be reviewed which operates as follows: Investment in nuclear fuel is considered an integral part of the utility plant investment, and thus becomes part of the utility's rate base. (The timing for introduction into the rate base and whether or not Allowance for Funds Used During Construction (AFDC) is permitted or not, etc., varies from jurisdiction to jurisdiction.) For investor-owned utilities, setting the permitted rate of return on the rate base is, of course, the central issue in the regulatory process and this sets the indirect or working capital component of nuclear fuel costs. In the analyses that follow, an Annual Fixed Charge Rate for working capital of 15-17% has been used as representative of that charged by investor-owned utilities today. The analogous rates for publicly owned utilities are significantly lower by virtue of the absence of factors for federal taxes, corporate profitability, and possibly local taxes, with a range of from 6.5 to 8% used in the subsequent analyses.

While a specific system of accounts is specified by the FERC, with prescribed times and procedures for inter-account transfers, the details of the accounting process are not central to an understanding of the problem at hand. The essentials of the accounting process can best be conveyed by the investment time diagrams of Figure II-1. All four patterns are based upon the disposal cost associated with a single kilogram of fabricated enriched uranium fuel as charged into the reactor. Figure II-1A depicts the investment pattern resulting from the typical accounting procedure. Under this procedure, the total cost of the charge set at $100/kgU for simplicity in this example, is collected from ratepayers during the period of power generation (assumed to be 4 years) and at a rate in proportion to the energy generation. These revenues are shown as negative values to denote the fact that they are collected in advance of the charge disbursal requirement, which does not occur until five years after the fuel is discharged from the reactor

FIGURE II-1. Fuel Disposal Investment Diagrams



and this revenue effectively reduces the fuel cycle investment (rate base) required. (The other capital requirements of the nuclear fuel cycle require investment prior to operation and are thus positive in this graphical presentation). However, by virtue of the fact that revenues from ratepayers are collected from 6 to 9 years in advance of the year in which the actual payment of the charge is made, these revenues are likely to be subject to income taxes on a basis of a "cash accounting system." The impact of such tax payments is to effectively have (assuming a Federal/State tax of 50%) the amount of these revenues available to the investor-owned utility to invest elsewhere in the fuel cycle. This is significant because the early availability of the disposal-related revenues from ratepayers acts to generate an "investment credit" which serves to offset the direct cost of the disposal payment itself. When the charge is actually paid, it is then fully acceptable as an expense item for income tax purposes thereby recovering the tax previously paid with the result that the total "original" monies collected from the consumer is now available for payment to the Government. This cash flow account balance is shown in Figure II-1A.

In practice, the accounting for these charges is much more involved with other accounts such as accumulated deferred income tax, etc., utilized to appropriately relate taxes and costs to current customers and accumulate data as required for rate making regulatory procedures. Alternative procedures such as escrow accounting are also being considered which would change the costing analysis. Utilizing the cash flow as summarized in Figure II-1A. and a 16.5% Annual Fixed Charge Rate the net cycle costs can be developed.

Investment credit = Average investment x Fixed charge rate x Time

$$\text{(Indirect Cost)} = \left[(1 - .5)\left[\underbrace{\left(\frac{100}{2} \times .165 \times 4\text{yr}\right)}_{\text{operating period}} + \underbrace{(100 \times .165 \times 5\text{ yr})}_{\text{holding period}}\right]\right] = 57.75 \ \$/\text{kgU}$$

The total net cost to the fuel cycle would then be direct cost minus the investment credit (indirect cost).

100$/kg - 57.75 $/kg = 42.25 $/kgU

The basic rationale behind this procedure, and one which is applied uniformly to all other portions of the fuel cycle, is that the costs of disposal (or any other portion of the fuel cycle) should be paid by those ratepayers using the power generated by the fuel in question. However, this ideal concept is difficult to realize in practice when the time between power generation and disposal becomes long, as is currently contemplated. In this case, the funds collected from the ratepayer who pays the (direct) disposal costs (and uses the power) benefit future ratepayers by reducing the fuel cycle investment burden that must be borne during the subsequent five-year cooling period. On the other hand, the populations of current customers and future customers are generally sufficiently similiar so that there are only nominal inequities in this procedure.

In the real world these relationships are somewhat different when the effects of inflation are considered. (Up to this point the analysis has been in constant 1978$.) If an average 6%/yr. escalation in disposal cost during the 5 year cooling period were assumed, then the Charge at the time of disbursal would actually be $133.80/kgU relative to $100/kgU ($1.06^5 \times 100 = 133.80$) collected at the beginning of the five year period. The additional payment required to offset escalation would have to be collected from the then current ratepayers, thereby offsetting the sum of the investment credit benefits that they would have enjoyed as the result of the previous ratepayer's disposal payment. In this example, the overall net disposal cost would then be \$76.05/kgU (after investment credit has been accounted for).

There is, of course, no income tax liability for publicly owned facilities and thus all revenues collected serve to generate an investment credit. For a typical interest rate of 7.5%, this credit amounts to 52.5% of the Charge so that the net fuel cycle cost of disposal is 47.5% of the direct cost.

Individual regulatory commissions may handle the development of the
13-q revenue requirements differently, depending upon when payments to the Government are due and how they are defined and could therefore develop other "investment credit" values. The standard procedure outlined above assumes the utility will collect the estimated disposal cost during the operating period. In a recent FERC survey of state commissions carried out in the spring of 1978[2] to obtain some comprehensive view of rate-making policies relating to nuclear fuel, it was found that many policies were still in a formative state. In the face of uncertainty as to whether reprocessing will be permitted, there has been some trend for utilities to assume a zero-net salvage value. About a third of the states responding on this point reported that zero-net salvage is being assumed in their jurisdictional filings, and rate cases. Some utility companies have adopted a "cost of disposal" concept rather than a positive or negative salvage value of spent fuel. If the DOE Spent Fuel Policy is implemented and the fee defined, regulators will be better able to treat disposal costs consistently in ratemaking.

To reflect other collection alternatives in this analysis, the variant pattern shown in Figure II-1B was considered. Here the fuel is assumed to be amortized to zero-net salvage value, and no disposal costs are collected during the power generation period. The revenues required to pay the Charge are then collected at the time of payment. This cost is then solely the direct Charge, and represents a direct cost impact on electricity costs. The equity of this approach is open to question in that it clearly places the cost burden of disposal on future ratepayers who have not benefitted from the use of the power generated by the fuel in question. The model used in Figure II-1B is actually a simplification of what might occur in practice in that it shows the accrual and disbursal to occur simultaneously. More realistically, accruals for the disposal expense might either lead or lag the actual disbursal, and might take place over some nominal period of time. This would modify the result only slightly, and thus has been omitted for the sake of simplicity.

Another alternative could consider the payment of the fee at a much earlier point in time. A prepayment 10 years prior to fuel shipping is illustrated in Figure II-1C. As in case "A" the fee is collected from the utility customer during the operating period but in this case the utility has a preinvestment so that the carrying charge must be added to the direct cost.

$$\text{Indirect Cost} = \underbrace{(100 \times .165 \times 1)}_{\text{pre-operation}} + \underbrace{\left(\frac{100}{2} \times .165 \times 4\right)}_{\text{operating period}}$$

$$= 49.5 \text{ \$/kg}$$

$$\text{Total Cost} = \text{Direct} + \text{Indirect}$$

$$= 100 + 49.5 = 149.5 \text{ \$/kg}$$

13-a In the case when the fee paid is open to alteration at a subsequent time to correct previous cost estimates, it is likely that similar collection practices will be observed for the basic fee. The method of collection of any adjusted charge - and allocation to the rate payers would be an additional item to be resolved with the respective public service commissions. One possible scenario is outlined in Figure II-1D and essentially represents a combination of approaches A and B, with the adjusted charge occurring at a later date after fuel discharge than is indicated in Figure II-1B. The concern mentioned with regard to Figure II-1B over the equity of collecting this adjustment from utility customers different from those who received the benefit of the power generated applies equally to this alternative. For the alternative in which prepayment is provided, the longer time between initial payment and ultimate disposition of spent fuel increases both the disparity between customers benefitting from the power generated and those paying for the adjustment and the probability that such an adjustment will be incurred due to changing cost factors and/or escalation.

These several examples* illustrate the range in fuel cycle costs that are possible for different fee payment times to the U.S. Government and for different collection philosophy from the utility customers. For a 100 \$/kgU fee the value accrued to the fuel cycle could vary from 42.25 \$/kgU for 5 year post payment to 149.50 \$/kgU for 10 year prepayment.

The mills/kWh_e has been developed under the typical accounting pattern for both PWR and BWR units, for both investor-owned and municipally-owned utilities. The following table summarizes these cost calculations for equilibrium plant operations and typical costing parameters.

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*Another possible pattern would be one in which funds to establish an annuity for payment of spent fuel storage and disposal costs are collected at the time of power generation. The objective would be to have the value of the annuity exactly equal to the cost of disposal at the time of disposal, say five years later. Establishment of annuities are not widely accepted in rate making by public service commissions and serious consideration of such a procedure would require that public service commissions would change their views.

EQUILIBRIUM FUEL OPERATIONS

COST OF STORAGE AND DISPOSAL SERVICES

Basis: Cost in Mills/kWh per 100 $/kgU charge

Payment at the time of transfer (5 years after reactor discharge)

Capacity factor 70%, Efficiency 32.5%

	PRIVATE UTILITIES Annual Fixed Charge Rate-16.5%		MUNICIPAL UTILITIES Annual Fixed Charge Rate-7.5%	
	PWR	BWR	PWR	BWR
	33.0 GWD*/MTU	27.5 GWD/MTU	33.0 GWD/MTU	27.5 GWD/MTU
Direct Cost M/kWh	0.38	0.47	0.38	0.47
Indirect Cost M/kWh	-0.21	-0.28	-0.19	-0.25
Total Cost M/kWh	0.17	0.19	0.19	0.22

* GWD - (Gigawatt-Day) - is a unit of energy consumption or generation in a given day. One Gigawatt=1000 Megawatts or 1 billion watts.

13-d A.2.2 Influence of Fee on Nuclear Decision

It has been generally considered that the demand for base load capacity in the United States is relatively insensitive to the cost of that additional energy and capacity within some reasonable band of future requirements. There is, of course, some elasticity of demand in the power generation field and this is briefly reviewed later in this section. There are effectively only two alternatives for base load capacity and these are coal or nuclear. One of the major influencing factors in the decision between these alternatives is that of overall economics. Considering that the reference projection of future nuclear capacity has been developed without a decision on a fee but also with an uncertainty regarding the ultimate availability and cost of service for the disposal of fuel, the setting of a fee can be influential in the decision-making process for individual units. Three alternative influences can be summarized as follows:

- Positive

  implementation of the Spent Fuel Policy and establishment of a fee result in reducing uncertainty associated with the nuclear fuel cycle and utilities significantly increase nuclear additions above the reference case;

- o Negative

13d the fee imposed is sufficiently high that nuclear power is generally considered uneconomic and nuclear additions are much lower than the reference case;

- o Neutral

  the fee imposed does not significantly alter the comparative economics of available generation sources, nor does the level of definition provided by the fee substantially alter the utility assessment of uncertainties among alternatives. Therefore, the reference projection remains unchanged.

In considering these several possibilities and the magnitude and importance of the positive and negative effects the nuclear decision is, on balance, considered to be unaffected by the fee at the full-cost recovery levels that are being considered. It is, of course, possible that some individual decisions may be negative because of the fee or others might certainly be positive.

The choice between base load generation alternatives is strongly influenced by the evaluation of total generation costs, consisting of a capital charge, a fuel cost, and an operations and maintenance charge. Average U.S. costs, based on regional estimates made by the Energy Information Administration (EIA) for nuclear and coal generation alternative units starting up in 1990, can be summarized as follows:[3]

	COAL		NUCLEAR
	With Scrubber	No Scrubber	
Capital-mills/kWh	14.6	10.6	17.1
Fuel	12.1	16.6	7.4
O&M	3.3	1.3	1.9
Total-mills/kWh	30.0	28.5	26.4

Although the U.S. average gives the general character of costs, individual plant decisions are based on the costs for a given location which have a much broader range of costs. For the coal plants, the fuel component varies significantly over various sections of the country, with the resultant total substantially greater or less than the average shown. For example, the difference between coal and nuclear costs cited[3] ranges from +7 mills/kWh in the New England region to -2 mills/kWh for mine mouth coal stations in two midwest regions. In their interpretation of these data EIA stated:

> "...In general the answer to the coal vs. nuclear question is too close to call in most regions because of cost uncertainties underlying the averages....". 3

It is within this cost region that nuclear plants are expected to capture on the order of 380 GW_e of U.S. generation capacity by the year 2000.

The key variable in the above summary for different regions of the country is
13d that of the coal fuel costs. In a recent Energy Information Administration Study[4] the variations in coal costs across the U.S. were developed. The lowest cost region, North Central, was 105¢/MBTU (equivalent to about 10 mills/kWh) compared to 183¢/MBTU (16.5 mills/kWh) for the New England Region average. Specific locations within each region also have a range, hence the U.S. range would be more like 8-18 mills/kWh. With such a wide variation throughout the country, a spent fuel storage and disposal fee, which would increase costs by 0.23 - 0.48 mills/kWh (the value resulting from 127-271 $/KgU for storage and disposal—(Table III.D.1)--would not bear on most of the nuclear/fossil decisions, particularly when the nonprecise nature of future cost projections are considered. (It has been estimated[3] that the certainty of future operating costs probably lies within ± 10% of the computed cost, a much wider range than that due to the fee).

If the fee varied by a substantial amount from the reference cost, and it will be shown subsequently that for "full-cost recovery" in a constant-dollar analysis such a large variation is not likely, the influence on the nuclear/fossil decision would still be minimal. Even a subsidy-pricing or a penalty-pricing basis, within the context of a factor of two or so, would still not change total generation costs very importantly.

This modest effect of the fee is further substantiated by a series of interviews with ten different utilities in which they stated:

> "Within the range discussed in Appendix A (115-161 $/kg)*, the fee level would not affect utility decisions. Unless the cost of storage and disposal increased significantly, the cost advantage would remain with nuclear power. One utility said that the competitiveness of nuclear energy would not be affected until the waste disposal cost increased to well above $500/kg."[5]

Utilities, responding to the Draft EIS, further supported this analysis of the potential impact of the fee. Specifically, the Edison Electric Institute has stated that it "concurs with the determination that the fee level and payment will not impact the growth of nuclear power".

Contrary to the general principle that an increase in costs causes a decrease in demand, utilities have expressed concern that the unknown cost for storage and disposal (or even more basically, an unknown as to what the disposal options might eventually be) would certainly have a negative influence on a nuclear decision. Therefore, the setting of that fee and the elimination of the unknown conversely will have a positive effect on some nuclear decisions. This particular effect is, of course, impossible to quantify but is, nevertheless, real. It is considered, then, that the relatively nomimal cost increase as a result of the setting of a fee considering the band of uncertainty relating to the coal-nuclear decision would result in a neutral effect. On the other hand, the fee can have an influence on the decision-making related to "at reactor" or "away-from-reactor" storage as discussed in Section II.A. Even these decisions, however, are further constrained by physical capacity of facilities on site, regulatory concerns and licensing considerations, so that establishment of the program and the fee would not reduce nuclear uncertainties related to alternative power sources to the point at which it would substantially impact on the choice between two systems.

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*This range was presented to utilities as an early DOE estimate and is not inconsistent with the fee level analyzed in the EIS.

13d With respect to the potential impact on overall demand for electricity, the foregoing analysis can be extended to consider existing data on both costs to produce specific types of power, and revenues received by the power companies as well as uncertainties currently faced by utility customers in terms of fuel adjustment clauses. Based on data compiled by the Edison Electric Institute costs of production in 1977 were 39 mills/kWh for oil units, 20 mills/kWh for coal, and 15 mills/kWh for nuclear. Revenues received from customers in 1978 averaged 34.6 mills/kWh for all types of services nationwide (with a range of 25.9 - 41.0 mills/kWh for different classes of service—e.g. industrial and commercial for the low and high values cited here) and the reference fee will therefore represent an even smaller fraction of the electricity cost to the consumer than of the power cost to the utility. As an indication of the changes that occur in pricing, which demonstrates the relatively insignificant effect of the fee, existing fuel adjustment clauses resulted in a range of Delta charges from -1.52 to +26 mills/kWh for residential users nationwide in January, 1979.

Studies conducted by the Electric Power Research Institute (EPRI)[6] have attempted to quantify the effect of price changes on the demand for electricity, a task that is complicated by its almost total empirical basis and the difficulty in isolating price effects from others such as weather, economic conditions, changes in competitive energy costs, etc. The studies cited in Reference 6 indicate that electricity demand is relatively inelastic in the short run and may be somewhat elastic in the long run. The long-run price elasticity estimates cited are:

-1.17 for residential customers (a 1% increase in cost causes a 1.17% decrease in consumption),
-1.22 for commercial, and
-1.00 for industrial (Table 6.4 of Reference 6).

It was emphasized, however, that this elasticity is reflective more of demand for energy (in kilowatt hours) rather than peak demand for power (in kilowattts). Decisions on capacity additions must reflect decisions by the utilities on the expected peak demand for power, and while it was emphasized that the data are still preliminary in nature, current data suggest a fairly inelastic response to price changes for this demand.

B. Unit Cost Development

c The fee to be charged for spent fuel storage and/or disposal is computed to recover full U.S. Government cost incurred to provide several different operations. Total costs are based on the summation of costs to provide each of the following facilities or services:

- Independent spent fuel storage (ISFS) costs.
- Transportation of spent fuel between interim spent fuel storage (ISFS) facility and geologic repository.
- Encapsulation facility costs. This facility, assumed to be located at the geologic repository, will receive spent fuel from reactors and/or ISFS's and package it for ultimate disposition.

c o Geologic Repository

In addition, estimates of research and development, carrying charges, and U.S. Government overhead incurred for the spent fuel storage and/or disposal program are included.

B.1 Shipping

The spent fuel transportation considered in this section is from the reactor basin to the U.S. Government facility where title is transferred, and from the ISFS facility to a U.S. Government geologic repository. Initial shipments by the electric utilities will be to an ISFS facility until the U.S. Government geologic repository becomes available. At that time shipment of spent fuel directly to the repository will commence initially on a limited basis until full scale disposal operation becomes established.

Transportation cost for spent fuel shipments from the ISFS to a U.S. Government repository is a component of the U.S. Government charge for spent fuel storage and disposal services. The basis and magnitude for this cost component is reviewed in the subsequent development. Although not included in the U.S. Government charge for spent fuel storage and disposal services, costs for spent fuel shipments from reactor basins to U.S. Government interim storage or geologic repository are of interest since utility evaluation of the alternatives will consider this cost component.

Transportation cost estimates presented in this section are consistent with the use of existing cask designs and lease of equipment from the private sector. As purely operating costs, without a separate research and development component, the costs considered are unit costs and are not sensitive to quantities of spent fuel to be shipped.

B.1.1 Reactor Plant to U.S. Government Interim Storage or Repository

The electric utilities will be responsible for shipping of spent fuel to a U.S. Government Independent Spent Fuel Storage (ISFS) facility or Repository. This shipping cannot be characterized simply since costs are highly dependent on the proximity of the reactor to the receiving facility. Also, some reactors will be capable of handling only truck casks while other utilities will elect to contract for spent fuel shipping in railroad casks.

According to Reference 5, shipment of spent fuel from domestic reactor basins to ISFS basin will be typically 1000 miles, and 30% of the fuel will be shipped in truck casks and 70% will be shipped in rail casks. The same split of truck and rail cask is presented for direct shipment from the domestic reactor basins to the geologic repository, however, a typical distance of about 1500 miles is used as the basis for evaluations. Typical transportation costs which are consistent with the reference distance are presented in Table II-1. The actual spread in costs for the individual utilities will be considerable depending upon the actual distances to be traveled, local transportation conditions and rates, and shipping cask contractual arrangements. In addition to the typical distance between domestic reactor basins, and the ISFS basin and Repository is the inclusion of a 500 mile distance for truck transport to show the sensitivity of a distance closer than the reference cases.

TABLE II-1

Summary of Transportation Costs for Shipment of Spent Fuel from Domestic Reactor Basins to Government Facility

	TRANSPORTATION COST*, $/kgU		
		Domestic Reactor Basin to ISFS Facility	Domestic Reactor Basin to Disposition Facility
	(500 miles)	(1000 miles)	(1500 miles)
1. TRUCK			
$500/day lease	10	15	21
$1000/day lease	15	22	29
2. RAIL			
a. Regular Service:			
$2500/day lease		23	33
$3000/day lease		27	39
b. Dedicated train:			
$2500 day/lease			
1 cask per train		29	41
2 casks per train		23	32
3 casks per train		21	29
$3000 day/lease			
1 cask per train		32	45
2 casks per train		26	36
3 casks per train		24	33
4 casks per train		-	31

Assumptions:

Typical truck and rail tariff
Dedicated train charge of $20/mile
Speed averaged over entire day:
truck - 30 mph
regular train - 4 mph
Typical loading and unloading time:
truck cask - 3 days
rail cask - 5 days

Cask capacities (60% PWRs & 40% BWRs)
truck - 0.42 MTU
rail - 3.3 MTU (IF-300 cask)

*Transportation cost only includes hauling, special train usage, and cask lease.

The lease rates and distances shipped are comparable with the referenced reports. Likewise the average speeds for truck and rail travel, and cask load and unloading times cited in Table II-1 are typical of values in the referenced Oak Ridge National Laboratory[7], former Office of Waste Isolation[8], and TRW[9] reports.

The individual cost values presented in Table II-1 are in reasonable agreement with the comparable values in Reference 13 since the calculation bases are quite similar. Table II-1 indicates that truck shipments of spent fuel from domestic reactor basins tend to be lower than for either regular train service or dedicated train service for the conditions assumed.

Dedicated trains demonstrate a clear economic advantage over regular train service, and even truck transport, only when multiple casks comprise the dedicated train. This apparent advantage may not be easily gained by the typical electric utility, however, since the availability of multiple casks and the tight scheduling required for their use would probably be the exception rather than the norm.

B.1.2 <u>ISFS Facility to Repository</u>

Reference 15 uses $31.5/kgU as the unit cost basis for transportation by the Government of spent fuel from the ISFS to the Repository. The detailed breakdown of this cost is presented in Reference 14. This unit cost can be better estimated than the cost for transportation from reactor basins, since a reference distance between points of origin and termination can be defined (in this case about 1600 miles), and the large quantity of fuel lends itself to close scheduling for full utilization of multiple casks on dedicated trains.

The underlined transportation cost in Table II-1 of $31/kgU is comparable to the reference value ($31.5/kgU) used in the preliminary estimates of the charge for spent fuel services by the U.S. Government.[10] The reference case mileage from the ISFS facility to the Repository is slightly longer, which could increase the underlined transportation cost slightly for even closer agreement with the
9-e reference unit cost. This cost information, although presented in slightly different form, is also consistent with related assumptions in Volume 2 of this EIS.

The reference unit cost for transportation seems to be a reasonable basis for this component of the U.S. Government charge for spent fuel services. Cask lease comprises about 73% of this cost and therefore actual negotiated lease rates would similarly affect this unit cost.

B.2 <u>Independent Spent Fuel Storage (ISFS) Costs</u>

B.2.1 <u>Capital</u>

A number of estimates of construction costs of away-from reactor spent fuel basins have been made. Because of its rather short life the cost for the interim storage of spent fuel is a strong function of the investment in the spent fuel basin and supporting facilities. The base costs used in the DOE estimates for the one-time-charge for basin storage are based on investment estimates made by DuPont at the Savannah River Laboratory.[11] An independent estimate has been made by the IAEA[12] recently, which, as is shown in Figure II-2, brackets the DuPont estimate at the 5000 MT size. Estimates have also been made by other sources as indicated.[13&14]

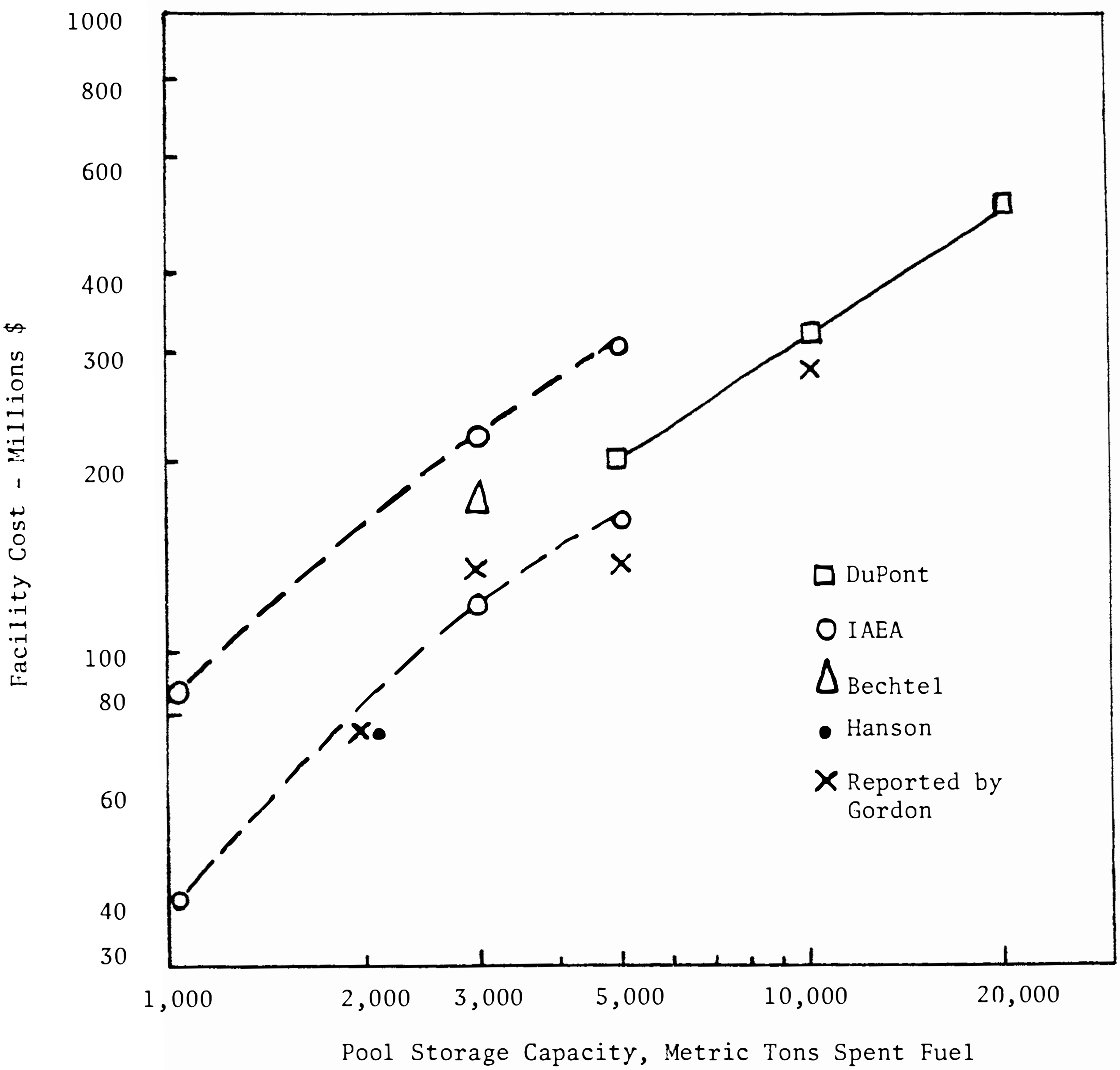


FIGURE II-2. Investment Cost for Independent Spent Fuel Storage Facilities

As can be seen the DuPont estimates follow the trend of the other estimates and are generally higher and therefore, from the point of view of estimating the fee, more conservative than most other estimates. The upper range of the IAEA estimates assume stringent safety provisions and that is the reason for their being generally on a trend that would be higher than the DuPont estimates.

B.2.2 ISFS Operating and Maintenance Costs

The ISFS operating and surveillance costs used were developed by DuPont at the Savannah River Laboratory. These are compared to other estimates of ISFS O&M and surveillance costs.

ISFS O&M costs are $6 million/year as estimated by DuPont. ISFS operations are almost entirely personnel oriented and no variation in costs was assumed for different amounts of fuel being delivered. This implies that the ISFS facility is staffed at the level of maximum receipt rate at all times.

The IAEA[12] estimates O&M costs ranging from ∿$6 million per year to $8 million per year at receipt rates ranging from 1500 MTU per year up to 3000 MTU/year. Hanson[13] has estimated O&M costs for a small repository (1000 MTU) at $1.25 million, and Gordon[14] reports a range of O&M costs from $4 to $7 million. On the basis of this comparison the O&M costs utilized in this analysis are reasonable.

B.2.3 Private versus Public Ownership of ISFS Facilities

The capital, O&M and decommissioning cost estimates provided herewith are independent of the mode of ownership or the type of financing. The level of the fee charged will, of course, depend upon the debt/equity ratio of the corporation tax structure, and fixed charge rate utilized by it.

In their analysis, TRW[9] assumed private ownership of the ISFS. In Reference 15 a private ownership mode was also considered. This mode of ownership increased the level of the fee 6% relative to the reference case due to the higher cost of capital for the private entrepreneur.

B.3 Geologic Repository and Encapsulation Facility Capital and Operating Costs

B.3.1 Capital Costs

Geologic repository costs are based on estimates developed by the former Office of Waste Isolation (OWI) at Oak Ridge. The geologic repository is assumed for this analysis to be in bedded salt and to encompass 2000 acres. The initial facility is designed to contain about 100,000 MTU of fuel but is loaded conservatively as a "first of a kind" facility to 45,000 MTU. The receipt rate is c 1800 MTU/year for the first five years during which the operability of the facility is "verified" and 6000 MTU/year thereafter. The capital cost of this facility is estimated to be $500 million.

TRW[9] estimated $596 million for a similar facility on the basis of the same sources. The major items of difference are treatment of contingencies, owners's cost, and the assumption of 25 year retrievability by TRW.

The basic data for these estimates was based on work previously carrried out for high level wastes and is therefore preliminary in nature. Clearly, additional design and analysis to provide more detailed estimates is required before the final cost estimates for the fee can be developed.

B.3.2 Operating Costs

Based on some work by OWI, previously discussed, estimates of operating costs and decommissioning for the geologic repository have been developed. As reported by TRW[9] the operating costs range from $77 million to $108 million per year. As estimated by PNL[15] a figure of $50 million per year was used for operating costs. Decommissioning costs of $198 million were reported by TRW[9] and PNL reported the same value for the initial repository and $138 million for subsequent repositories.[15] As seen in Table II-2, the decommissioning cost is
13-1 estimated to be lower for a 100,000 MTU repository than a 45,000 MTU repository because the latter maintains a waste retrievability criterion which adds to the decommissioning changes. Like the repository capital costs these are preliminary figures and subject to review as more detailed designs evolve.

B.4 Encapsulation Facility

Capital cost estimates for an encapsulation facility have been developed based on conceptual designs studies by OWI[9] and also Rockwell Hanford
6-e Operations[15] of a facility sited at the geology repository. For conservatism, the higher figures ($287 million) as estimated by PNL for a similarly sized facility based on the Rockwell work were used in this analysis. Annual operational costs range from $20 million for 6000 MTU/year of fuel processed to $10 million for 2000 MTU/.year of fuel processed. The estimates are by TRW[9] based on the OWI work. PNL estimated costs at $31 million per year for 6000 MTU of fuel processed based on the Rockwell work.

Decommissioning costs for the encapsulation facility were estimated to be $26 million as reported by TRW. No decommissioning costs were reported by PNL.

Table II-2 summarizes the capital, operation and maintenance and decommissioning cost for the storage and disposal operations.

C. Pricing Methodology

C.1 Procedures to be Followed

The pricing procedure to develop the fee is one of projecting the future cash flow requirements for both capital and operating costs over the total period being evaluated and then developing the revenues obtained from the utilities for purchase of the storage and disposal service. For the case in which facility lifetimes extend
13-g beyond the time period evaluated (notably the geologic repository) costs for the entire facility are analyzed and appropriately apportioned to the fuel emplaced during the evaluation period. The present worth of the total costs and the total revenues are made equal to each other utilizing a 6.5% present worth factor, and hence any difference in these two cash flows are debited or credited at the Government debt rate. The result of this procedure is "full cost recovery" to the U.S. Government. If the U.S. Government advances money for the construction of facilities they then eventually receive that money back with the full interest that they have to pay and hence the early investment by the U.S. Government is at "no

TABLE II-2

Summary of Unit Costs for Facilities and Services

COMPONENT	CAPITAL	OPERATION AND MAINTENANCE	DECOMMISSIONING
	(Millions of '78 $)	(Millions of '78 $/Year)	(Millions of '78 $)
Transportation	----	31.50/kg	---
ISFS			
1,000 MTU	19.2	Included with larger base module	Included with base module
5,000 MTU	201	6	20
10,000 MTU	322	8	28
Encapsulation Facility			
6,000 MTU/year	346.4	21.2 million fixed 0.00384/canister	Included with geologic repository
9,000 MTU/year	519.6	31.8 million fixed 0.00384/canister	
Geologic Repository			
45,000 MTU	500	50.00 0.004965/canister first 5 years 0.001965/canister thereafter	198.35
100,000 MTU	515	54.30 0.005007/canister first 5 years 0.002007/canister thereafter	137.653
R&D and Gov't. Overhead	560.4 (1977-1986)	13.0 (1977 on)	

cost". This procedure is generally known as a discounted cash flow analysis and is used extensively in industry to equate expenditures and revenues over different time frames. Such a procedure also makes the U.S. Government "indifferent" to alternative revenue timings since the bottom line of costs balance is zero regardless of the timing of revenues. On the other hand, it is clear that earlier payments reduce the total investment basis and therefore more or less funds must be appropriated depending upon the specific procedures and timing of the fee payment.

The utilities' view is substantially different because their present worthing factor is higher and is dependent upon their annual fixed charge rate and, further, their costing is for a different time period; that between the actual generation of power from a given batch of fuel and the payment of the storage and disposal fee for that fuel. This was reviewed earlier in a generic way and is quantified for the reference case in Section III.C.

The estimation of costs for storage and disposal will be revised periodically as actual facilities are constructed and so the expenditures made for embedded costs are used when such information is available, in addition to revised estimates of future expenditures. When these cost changes are significant, the announced fee schedule for future storage and disposal will be modified so that the total of all revenues as projected will be equated to the then current revised cost estimate. In other words, the fee charged for services will float in the future to appropriately reflect revenues to the Government equal to the cost to the Goverment with both revenues and cost adjusted by the 6.5% present worth factor. Appendix A provides additional detail and the mathematical formulations used for the costing procedure that may be used in establishing a full cost recovery fee schedule.

Within this framework of full cost recovery the actual payment times can be early, at the time of transfer of fuel, subsequent to the transfer of fuel, a single payment, or multi payments. These alternatives will be viewed differently by the utility industry with certain of the alternatives being more adaptable to the utility regulatory environment while others would represent problems in the allocation of the fee paid by the utility to the electricity consuming customers.

The reference payment scenario assumes that a "one-time-fee" is paid at the time the fuel is transferred to the Government (not earlier than 5 years after the fuel has been discharged from the reactor). Fuel may be transferred to the Government for ISFS storage followed by disposal, in which case the fee is established to recover the cost of both of those services. Alternatively, depending upon the timing, the fuel may be transferred for disposal alone, in which case the fee would be less and be calculated for that service alone.

C.2 Difference in Projected Costs

Following the procedures generically outlined above, if the future expenditures by the U.S. Government were those actually achieved (perfect cost foresight) and the spent fuel flows were as projected, the level of cost developed would not change over time, that is, it would be the same dollars per kgU whether the service was purchased in 1985, 1990 or 1995, etc. As perfect foresight cannot be achieved, future costs will be either higher or lower than that projected and hence there would be a mismatch between discounted revenues and discounted costs unless there were adjustments to the fee--thereby changing the projected discounted revenues to match the fee.

The question might be asked as to whether changing a "one-time-charge" can be dealt with in the proposed pricing structure. The most common change in future costs which can easily be hypothesized is that of escalation; wherein if no allowance has been made for future escalation (the analysis being done in constant dollars) escalation will certainly increase future costs. As this escalation actually occurs, the then current costs will be greater than that projected a year or several years earlier and hence the fee charged at that point in time. In fact, this increase in cost applies not only to the fuel then being received, but some of that increase in cost must be allocated to increased costs incurred for fuel, which has already been received and paid for. Because of the continuing and expanding nature of the fuel flows this increase in cost is fully capable of being dealt with without extraordinary increases in fee as compared to the fee paid earlier. This kind of effect is quantified in the implementation section of this report, III.B.

An alternative adjustment procedure could consider the fee payment at some earlier time with a second adjustment fee to account for escalation at the time of fuel transfer. It would also be possible to consider other "corrections" on delivery. These secondary types of adjustments result in some difficulties for the utilities to implement as the second payment if not fully defined cannot be correctly allocated to the utility customers during the operating period.

Implementation of a fee system which provides the ability to correct for changing cost factors-whether due to escalation, underestimation of facility costs, change in facility design, etc.-up until the time at which spent fuel is ultimately disposed, offers the advantage of maintaining responsibility for a specific batch of fuel with the utility who generated it. No inequity is introduced, therefore, between costs incurred by early and late users of the storage and/or disposal services.

The Government and utilities have a somewhat different view of a "one-time-charge" in which a later fuel bears some of the costs of earlier fuels. For example: Assume that a utility has paid for a first batch of fuel at 100$/kgU and has paid for a later batch of fuel at 150$/kgU. Each of these payments represent a "one-time-charge" for that particular batch of fuel as viewed by the utility. The Government's view on the other hand sees 100$/kgU for the first batch, which charge has been shown to be insufficient in a later analysis, and therefore a charge for the later batch of 150$/kgU was levied. The "correct" allocation should have been 125$/kgU for both batches and therefore the original 100$/kgU was not a "one-time-charge". The alternative, however, of back charging 25$/kgU on the first batch presents the utility with some accounting and regulatory problems, hence the 150$/kgU charge which does recover full cost to the Government is a preferred approach from the utility point of view.

C.3 Pre and Post Payment Alternatives

There could be any number of payment time alternatives for a charge. For example, such times could vary from payment at the time of Separative Work Payment, to payment five years before delivery, to payment subsequent to delivery and/or any combination of these or even wider spread alternatives. The level of the fee would be somewhat different depending upon when the payment is made but a more important effect would be on the investment requirements by the U.S. Government. Clearly, very early payments would minimize "new money" investment because the fees collected would in fact pay for the capital costs of facilities and their future operations costs. Conversely, payment after receipt of fuel would require a maximum investment on the part of the U.S. Government because facilities would have to be built and operated for awhile before the revenues were received. This effect has been quantitatively developed by DOE in their analysis of several payment alternatives and is illustrated in Figure II-3. This analysis, which assumes constant 1978 dollars and perfect foresight of future costs, indicates the cash flow position by the U.S. Government could vary from a maximum of approximately $800 million (present worth $) to a negative investment of about the same magnitude. The notes on this Figure summarize the several payment schedules evaluated.

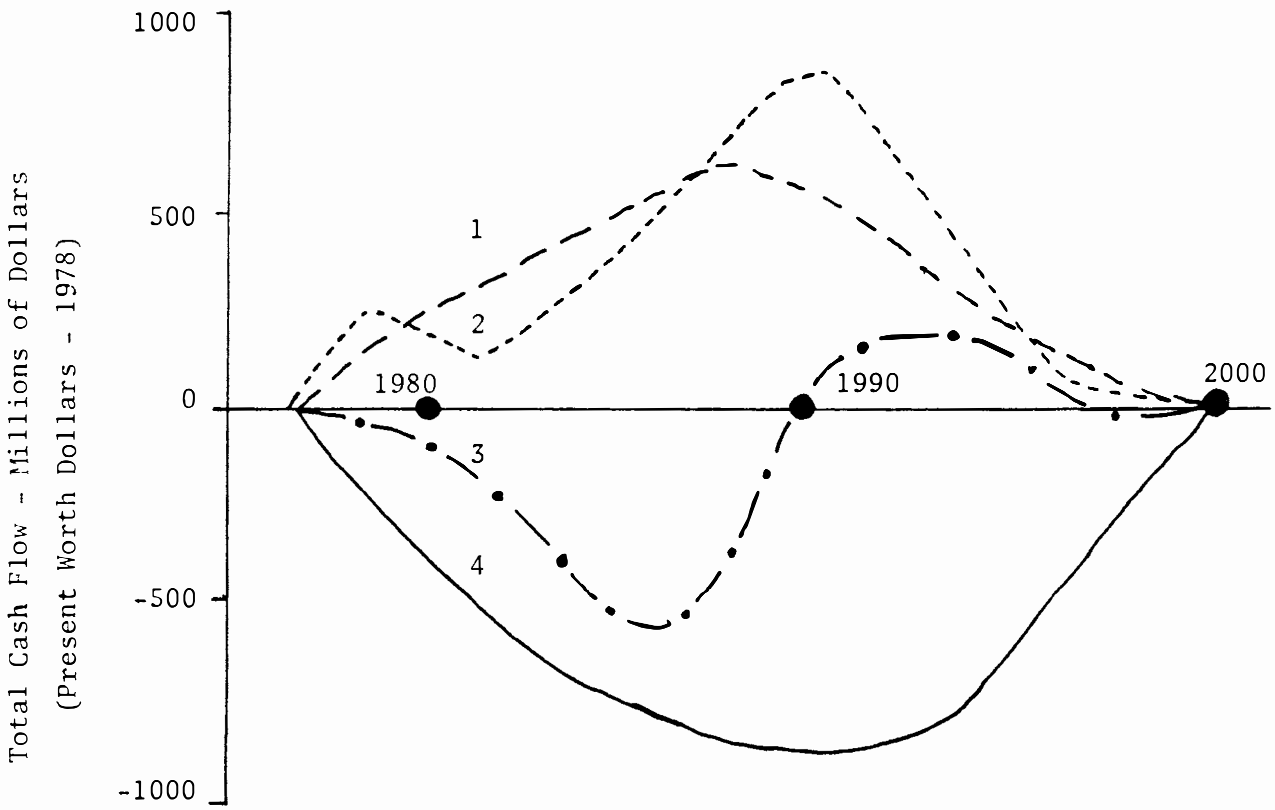
Recognizing that there are always competing demands for available funds in
today's society, minimization of U.S. Government investment in the spent fuel
13-i storage program should be another consideration in establishing the fee and
payment time. Although in terms of achieving full cost recovery, the U.S.
Government is indifferent to the time of payment of the fee, it is possible that
some cash flow considerations may favor a specific payment time alternative. As
further discussed in Section IV.A.4, the range of spent fuel flows and related
environmental effects evaluated in this EIS would remain unchanged if payment
time were specified at other than the time of transfer assumed in the reference
fee.

It should be noted that if earlier payments are made there is a much higher probability of change in the future payments because less is known about the actual expenditures as they will occur. Further, if no assumption as to further escalation is made and an allowance for such escalation included, this factor alone could cause significant variation in early payments of fees as compared to the later payments. One of the advantages of a later payment schedule is that it would reflect a more correct value for the full recovery of costs associated with a given batch of fuel. A very early payment schedule on the other hand could cause the early batches of fuel to be significantly undercharged and therefore necessitating adjustments to either all fuel or merely to future transfers to maintain full U.S. Government cost recovery.

C.4 Single and Multiple Cost Centers

In developing a "fee" the actual payment could be made at a single point in time, at different points in time, for a total service of storage and disposal, for disposal alone, or a single payment for everyone whether they needed interim storage or not. From the U.S. Government point of view the revenues can be balanced appropriately against cost no matter which of these alternatives is utilized and the costing procedures used are slight modifications of that described above.

The utility view of these alternatives, however, is quite different and may influence them to proceed differently in both their service requirements and their timing. This difference in timing and/or service requirements can have an environmental effect which is quantified in Section IV.



Fee Payment at Time of:

1. Enrichment
2. 10 Years Before Transfer
3. 5 Years Before Transfer
4. Transfer (5 Years After Reactor Discharge)

FIGURE II-3. Storage/Disposal Cumulative Cash Flow for Material Stored and Disposed thru Year 2000

References for Section II

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III. IMPLEMENTATION OF PRICING POLICY

A. Development of Reference (Nominal) Cost Case

A.1 Development of Base Reference Data

c The reference or most probable cost case is determined by equating total revenues to total expenditures based on nominal annual spent fuel flows (from reactor to ISFS, from reactor to repository and from ISFS to repository) and annual cash flows for each service or facility used. In other words, total cost equals total income, with appropriate weight given to the timing of each. Each of the input parameters of this calculation may vary - depending upon the particular estimating procedure used to determine a particular item or the weight given to various factors by a U.S. utility or foreign country in deciding to transfer spent fuel.

A.1.1 Domestic Reference Case

In light of current U.S. policy, one must consider the eventual disposal of spent fuel as waste. There are some options as to how to arrive at the disposal point but the total quantities for disposal are basically set by the embedded and committed nuclear power facilities. Operating plants and those already committed
13-n represent over half the total expected on line through the year 2000. Table III.A.1 summarizes the reference flows to the ISFS and to the repository based on the nominal cycle of the ISFS in operation in 1983 and the repository in operation beginning in 1988.[1] Utilizing these material flows and the unit cost data as summarized in Section II.B., a cost of service of $227/kgU for storage and disposal and $117/KgU for disposal only has been developed. These costs are distributed in accordance with Table III.A.2. It should be noted that these costs are in 1978 dollars and represent the average payment due at the time that spent fuel is transferred to the Government. These values further assume that the costs and the material flow develops as projected and no escalation or contingency costs are accrued. As noted in the DOE report on preliminary estimates of the Fee,[2] use of this reference case is not intended to indicate that it is the most likely one to evolve. The purpose of this Volume of the EIS is to evaluate the impact on the environment of various methodologies for establishing a fee for the storage and/or
6-c disposal of spent fuel. The reference fee has incorporated several conservative features and no attempt at economic optimization has been incorporated. The following analyses in Section III.B indicate the variation in price that may occur with perturbations from the reference values. They have been developed to explore the sensitivity of the fee and fee structure to various situations which may evolve.

A.1.2 Reference Case Including Foreign Fuel

It is not possible to predict the exact quantities of foreign spent fuel which may be sent to the U.S. under the Spent Fuel Policy announced in October 1977 since this would depend on a number of variables including the policy and economic decisions of foreign governments and utilities regarding the optimum means of handling their spent fuel. Such decisions will be based on the cost and availability of alternatives including expanded national storage or reprocessing) and non-proliferation considerations. A discussion of these matters is more fully set out in Section II.D of Volume 3.

TABLE III.A.1

Spent Fuel Movements - Reference Case
(Metric Tons of Heavy Metal)

Year	ISFS Facility			Geologic Repository		
	Annual Shipments		Inventory	Annual Shipments		Inventory
	Domestic	Foreign		Domestic	Foreign	
1983	978	110	1088	--	--	--
1984	429	50	1567	--	--	--
1985	506	65	2138	--	--	--
1986	605	70	2813	--	--	--
1987	655	80	3548	--	--	--
1988	(1012)	--	2536	1710	90	1800
1989	(953)	--	1583	1705	95	3600
1990	(840)	--	743	1690	110	5400
1991	--	42	785	1727	73	7200
1992	--	120	905	1800	--	9000
1993	--	130	1035	6000	--	15000
1994	--	135	1170	6000	--	21000
1995	--	145	1315	6000	--	27000
1996	--	150	1465	6000	--	33000
1997	(368)	(122)	975	6368	282	39650
1998	--	(490)	485	6000	655	46305
1999	--	(485)	--	6000	665	52970
2000	--	--	--	6000	190	59160

Notes: 1) Domestic shipments from Table 3, Reference 1.
2) Foreign shipments from Table II-1, Volume 3, Option 1, and private Communication.

TABLE III.A.2

Elements of Fee - Domestic Reference Case ($/kgU)

	Disposal Only	Storage and Disposal
ISFS	--	104
Transportation	--	26
Encapsulation	34	26
Geologic Repository	51	39
R&D and Gov't. Overhead	32	32
Total	117	*227

*Note: The charge here differs slightly from that in DOE/ET-0055 since the ISFS is not emptied as quickly.

A related question, however, is whether the handling of foreign fuel significantly or importantly changes the U.S. fee structure thereby causing a change in environmental effects due to the change in the domestic users' view of the service provided. Such a change would primarily be in the area of the ISFS charge since these costs are relatively sensitive to a changing materials flow characteristic to and from the facility. The estimates of foreign participation based on the delivery schedule shown in Table III.A.1 were chosen as reference foreign cases to assess the potential participation on the fee. This is compatible with the philosophy that individual countries will manage their own spent fuel storage and disposal to the fullest degree possible. The lowest estimated flow for foreign fuel combined with the reference domestic flow results in a storage and disposal cost of 202 $/kgU and disposal only cost of 114 $/kgU compared to 227 $/kgU and 117 $/KgU respectively, for the reference domestic case.* This decrease in cost is generally characteristic of higher demand as was illustrated in the DOE preliminary estimates. It might be concluded therefore that in this case foreign participation results in a reduction in cost to U.S. utilities. Therefore, its inclusion has a positive economic effect. Volume 3 of this EIS has evaluated a range of likely amounts of foreign spent fuel that may be transferred to the U.S. under the Spent Fuel Policy. This range is from 2160 MTU to 13,580 MTU. For purposes of evaluating the potential environmental effects, the maximum quantity of spent fuel was considered and is discussed in more detail in Section IV.

A.2 Reference Unit Costs

The allocated costs for the several components of the spent fuel handling and disposal program have been developed in Section II.B and the resultant distribution of the total charge for the reference case is summarized in Table III.A.3. Depending upon when payment is received, what the material flows are over time, etc. each of these fee components will vary and under certain circumstances the variation can be significant to the customer. These perturbations are reviewed in Section III.B.

B. Perturbations of Base Case

To evaluate the sensitivity of the reference fee to changes in assumptions several variant cases were analyzed and are discussed in this section:

- Demand Variations
- Facilities and Service Variations
- Fee Structure Variations
- Payment Alternatives
- Facility Ownership
- Escalation
- Major Future Changes

B.1 Demand Variations

The extent of the effect of demand variations on the fee level is reviewed in this section. The intention here is to provide a range of possible fees reflecting the uncertainty in the exact schedule of participation by domestic and foreign

*The lowest estimate for foreign fuel was chosen to give the highest unit cost.

TABLE III.A.3

Elements of Fee - Reference Case - Domestic & Foreign Fuel ($/kgU)

	DISPOSAL ONLY	STORAGE AND DISPOSAL
ISFS	--	89
Transportation	--	24
Encapsulation	33	23
Geologic Repository	50	35
R&D and Gov't Overhead	31	31
Total	114	202

customers in the U.S. Government's voluntary program for storage and disposal of spent fuel and in the actual schedules and operating experience of plants coming on line through the year 2000. Therefore, a high and low range (rather than every possible variation) has been developed.

c The low domestic demand case corresponds to the low demand analyzed in the DOE preliminary charge estimate document[1]. (Table III.B.1). These figures assume some degree of compacted at-reactor storage and consider domestic facilities only. The fee corresponding to this low demand case is $234/kgU for disposal only and $449/kgU for storage and disposal. The significantly higher cost reflects the fact that total facility costs must be recovered from a smaller base and therefore the unit cost increases. It is clear that this case would require a substantially smaller ISFS than the minimum 5000 MTU facility assumed in the costing analysis to date. An optimization of this facility as well as the repository
3-f could significantly reduce these costs. As more definitive requirements estimates are developed optimization of facility sizes and timing would be performed in establishing the final fee.

c The high domestic demand case (Table III.B.2) is based on the fuel flows developed in Volume 2 as well as a high estimate for foreign participation of 13,580 MTU from Volume 3. The geologic repository is assumed to begin operation in 1985 (for consistency with the reference cases of Volumes 2&3). This enables illustrative comparison of demand effects on the fee and the effects of a different repository startup date are included in Section III.B.2.2. Environmental effects are discussed in Section IV.

As would be expected from the preceding discussion, the higher flows result in better utilization of facilities and consequently a lower unit cost. Again the fee for storage and disposal is more significantly affected ($127/kgU) than is the disposal only charge ($83/kgU) since the demand difference is greatest for the ISFS.

B.2 Facilities and Service Variations

B.2.1 Single Geologic Repository

In developing the reference fee structure it was conservatively assumed that
6f an initial repository of 45,000 MTU capacity would be operated followed by a second repository of 100,000 MTU capacity as demand rose. The capacity difference resulted from assumptions regarding desired long-term retrievability and thermal loading limits and related emplacement and operating procedures. However, it could be assumed that the initial fuel emplaced will be loaded in a non-
E retrievable manner, thereby allowing use of a single 100,000 MTU geologic repository for the first installation, and resulting in a slightly lower charge than the reference case ($105/kgU for disposal only and $218/kgU for storage and disposal).

6-d While it is generally agreed that initial operation of the repository will occur at a conservatively low receiving rate until operability is proven, the exact value is still somewhat arbitrary and for this review the rates of 1600 MTU/yr. for the first five years and 6000 MTU/year thereafter have been used for consistency with other studies cited in Section II (p. II-17)

TABLE III.B.1

Spent Fuel Storage/Disposal Requirements - Low Case

	ISFS		GEOLOGIC REPOSITORY	
Year	Annual Shipment	Inventory	Annual Shipment	Inventory
1983	978	978	--	--
1984	429	1407	--	--
1985	(1294)	113	1800	1800
1986	(113)	--	718	2518
1987	--	--	655	3173
1988	--	--	698	3871
1989	--	--	752	4623
1990	--	--	850	5473
1991	--	--	995	6468
1992	--	--	1011	7479
1993	--	--	1111	8590
1994	--	--	1199	9789
1195	--	--	1320	11,109
1196	--	--	1427	12,536
1997	--	--	1571	14,107
1998	--	--	1714	15,821
1999	--	--	2604	18,425
2000	--	--	2902	21,326

*Numbers in parentheses represent shipments out of the ISFS facility.

Source: DOE/ET-0055 "Preliminary Estimates of the Charge for Spent-Fuel Storage and Disposal Services", U.S. Department of Energy, July 1978. Table 1.

TABLE III.B.2

Spent Fuel Storage/Disposal Requirements

High Case - MTU Spent Fuel)

Year	ISFS Facility Annual Shipments Domestic (a)	Foreign (b)	Inventory (c)	Geologic Repository Annual Shipments Domestic (a)	Foreign (b)	Inventory (c)
1978	--	--	--	--	--	--
1979	--	--	--	--	--	--
1980	--	--	--	--	--	--
1981	--	--	--	--	--	--
1982	--	--	--	--	--	--
1983	970	541	1511	--	--	--
1984	1580	417	3508	--	--	--
1985	1602	443	5553	100	--	100
1986	468	620	6641	1600	--	1700
1987	736	540	7917	1600	--	3300
1988	--	--	7917	3155	440	6895
1989	--	--	7917	3368	480	10743
1990	--	--	7917	3760	530	15033
1991	(530)	(181)	7206	4698	781	20512
1992	(1410)	(390)	5406	5863	1050	27425
1993	(1300)	(700)	3406	6076	1450	34951
1994	(1300)	(700)	1406	6326	1530	42807
1995	(816)	(590)	--	6297	1490	50594
1996	--	--	--	5478	970	57042
1997	--	--	--	5505	1080	63627
1998	--	--	--	5965	1170	70762
1999	--	--	--	6018	1260	78040
2000	--	--	--	6406	1350	85796

* Numbers in parentheses represent shipments out of the ISFS facility.

Source: Domestic Flows - Table III-2, Volume 2.
Foreign Flows - Table II-1, Volume 3 and private communication.

B.2.2 Delay of Geologic Repository

The effect of delay in the geologic repository for five years is primarily to require additional ISFS capacity prior to that time.* In terms of the fee, the disposal only cost ($110/kgU) decreases slightly from the reference case since two repositories are assumed to start operating within two years of each other and would receive fuel at about the maximum possible rate. This enables all the fuel stored at the ISFS basins to be transferred prior to the year 2000. This efficient use of facilities results in the slightly lower fee.

The storage and disposal fee ($165/kgU) also decreases due to the more efficient utilization of the ISFS capacity built.

B.3 Fee Structure Variations

As was described in Section II.C.3, a fee may either be developed on the basis of recovery of total system costs from all users ("levelized" methodology) or recovery of the cost of individual services such as ISFS and shipping or disposal only from those who use them. In each case, however, total costs are recovered.

The use-based methodology used as the reference case results in fees which bracket the "levelized" value. This "levelized" value is $125/kgU for the reference flows described in Section III.A.1 and the corresponding use-based values are $114/kgU and $202/kgU for disposal only and storage and disposal respectively.

Using a levelized methodology has the advantage of charging all customers the same fee but will result in the customers who deliver fuel at an early date and require ISFS storage and shipping to the repository paying somewhat less than full cost for those services. The difference will be made up by customers delivering fuel directly to the repository at a later date but paying a fee that includes an ISFS and shipping component. since both early and late customers are likely to be the same group of utilities, there is not necessarily a major inequity in this system.

B.4 Payment Alternatives

B.4.1 U.S. Government View of Payment Schedules

As reviewed in Section II.C.3 the payment at different points in time can result in significant differences in the U.S. Government's investment requirements (See Figure II-2). Illustrating the effects on fee level, assuming three possible payment times for full cost recovery of storage and disposal, utilizing an assumed 6.5% cost of Government money (a value representative of a longer term average), results in the following charges.

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*This five-year delay was assumed to be consistent with the DOE Charge Document and to illustrate that delay costs can be appropriately factored into the charge. Should additional delay occur, the charge will reflect the extended storage operation incurred.

108 $/kg - Payment 10 years before transfer
147 $/kg - Payment 5 years before transfer
202 $/kg - Payment at transfer (5 years after Reactor Discharge)

All of these cases represent the same basic direct cost data, the difference in fee only reflecting the time value of money.

B.4.2 Utility View of Payment Schedule

The utility view of the fee for different payment times is different from that of the U.S. Government because of their different annual fixed charge rate, 16-18% per year as compared to 6.5% per year. Using the same illustrative case as above the storage and disposal charge is $202/kgU when paid on delivery and this can be equated to a direct allocated cost of 0.81 mills/kWh. (electrical conversion efficiency of 34% and an average burnup of 31,000 MWD metric ton of uranium). Assuming an annual fixed charge rate applicable to the nuclear fuel investment of 16%/yr Table III.B.3 summarizes the fee data for other payment times. Both the direct cost and the total fuel cycle allocation which considers both the direct charges and the carrying charges associated with that cost, are included.

B.4.3 Charge Adjustment Procedures

The reference fee case has been developed on the assumption of perfect fore-knowledge of system component costs and flows which enables the development of total costs and fees which are unchanging with time. As it is clear that costs as they actually develop, will be different from those projected, adjustments in the fee will be necessary to appropriately reflect the changing conditions.

A "rolling average" cost over the past and projective years can be developed into which trends (including escalation trends) and changes can be factored gradually so that "step" changes in fee are minimized. In this "average" past unpredicted expenditures can be included in the ever expanding fuel service base of the current and future years.

An alternative to a forward rolling average would be a "back charge". For this alternative, corrections to fees already charged as a result of increased costs, escalation, incorrect flows etc. would be billed (or credited) as an additional fee to the utilities. As far as the Government is concerned this would allocate "full cost recovery" to the actual fuel in question. Provision can be made to apply
13-t corrections to the charge at various time - sup to and including the time at which ultimate disposal occurs - to enable the Government to recover the actual cost incurred for each specific batch of spent fuel. The method retains financial responsibility with the utility generating the fuel for the longest time possible and avoids any inequity between early and late customers. Such a procedure, which is clearly feasible from a Government view, results in some problems for utilities.

13-t It seems apparent that a "back charge" adjustment would be made after the fuel has been discharged from the reactor and hence would not necessarily be paid for by the utility customers who actually received the power generated. This is counter to the general principles of utility rate making and hence could present difficulties to both the utility and the public service commissions. If the change were not large, implementation could probably be managed. If it became substantive, resolution of the conflicting regulatory principles could be difficult.

TABLE III.B.3

Effect of Payment Time on Fuel Cycle Cost

BASIS: Storage and Disposal
Levelized Cost on Delivery 202 $/kgU
Utility Annual Fixed Charge Rate - 16%
Reactor Operating Period 3.5 yrs.
Thermal Efficiency 34%
Fuel Burnup 31,000 MWDt/MTU
Direct Charge Collected During Operation

	Fee Payment Time to Government		
	10 years prior to transfer	5 years prior to transfer	At transfer (ref. case)
Fee $/kgHM	108	147	202
Fuel Cycle Cost			
Direct M/kwh	0.42	0.59	0.81
Indirect	+0.24	-0.09	-0.45
TOTAL M/kwh	+0.66	+0.50	+0.36

B.5 Facility Ownership

The reference fee assumes that required ISFS capacity and transportation services to the repository will be provided by the U.S. Government. The possibility exists, however, that this service could be provided by a private enterprise and a different set of costs would evolve reflecting the change in cost of money (e.g. 12% rather than 6.5%). The effect of such a change would be in the storage and disposal cost and not the disposal only charge. Based on the domestic fuel flows E only, such a variation would result in a fee of \$271/kgU for storage and disposal rather than the basic \$227/kgU.

C The charge methodology, as developed, includes sufficient flexibility to allow computation of the fee based upon costs of purchasing existing ISFS capacity as well as construction of new capacity and this would be done if such a choice were made. It is not expected that the costs of purchasing existing ISFS capacity would differ, sufficiently from those used in developing the reference fee to result in fees outside the range already analyzed.

B.6 Escalation

The currently proposed methodology for computing the fee provides the possibility of adjusting any prepaid portion of the fee to reflect inflationary changes between the time of an earlier payment and the time of transfer of the fuel to the U.S. Government[3]. There is no provision, however, for incorporating inflationary effects subsequent to the time of transfer. Because of the long time periods possible between transfer of fuel - and payment - and incurrence of final costs of disposal and decommissioning of the repository (a period of up to about twenty years in extreme cases) there is the risk that actual costs will differ substantially from the estimates used to compute the fee, since future inflationary (and/or deflationary) trends in the economy may cause expenditures to vary from the level projected at the time of payment. This situation may be reconciled in any of several ways; e.g., by considering possible inflationary effects to the time of service (projective or perfect foresight method) in computing the fee, by including in the contingency allowance some provision to soften the impact of inflationary effects or by shifting the costs (rolling average) to later customers (this introduces some advantage for users of storage and disposal services compared to disposal only customers, but since it is likely that the same people will be in both groups this does not appear to be a major inequity).

The difficulty in adopting the first solution (essentially considering escalation to the time of service) is that no model is ever likely to predict the dynamics of the economy precisely and therefore it will introduce inaccuracies and the potential need for later adjustments which are inconsistent with the total concept of a "one-time-charge" used as the current reference. In addition, such a pricing mechanism would yield a levelized price which was inequitable to the early users of both the disposal only and storage and disposal services since their payments - which would be equal to those paid by later users - would be made in currency of higher purchasing power.

There has been precedent in the enrichment pricing mechanism for utilizing a contingency "fee" to offset inflation. The comparison of related impact is not exact, however, because a much higher proportion of the costs reflected in the payment made for separative work received in a given year stem from expenditures made either prior to or in the year in which payment is made.

13-p The purpose of this environmental impact statement is to evaluate the environmental effects of alternative methodologies that could be used in establishment of the fee. Escalation considerations will have to be included regardless of what methodology is adopted and the specific approach will be defined when definite contract provisions are developed.

B.7 Major Future Changes

In evolving a "one-time-charge" for interim storage and ultimate disposal a specific growth scenario and a requirements analysis for these services were evolved. Based on this nominal scenario and the use of cost data reviewed earlier in Section II the price for services to be supplied has been developed. This price of course is subject to a full range of engineering and technological uncertainties as well as to licensing questions, variation in materials flow, timing changes, etc. These variations result in normal error bands which are not uncharacteristic of engineering procedure and the effects of these error bands can be covered by determining the high and low values and thereby setting a nominal "contingency" kind of value which would encompass such uncertainties.

B.7.1 Major Contingency Considerations

In the past there have been major changes in the back end of the nuclear fuel cycle which have resulted in initial cost estimates or embedded funds set aside for such waste treatment or handling to be not sufficiently conservative.

One circumstance illustrative of the unknown characteristics of the back end of the nuclear fuel cycle was the technical decision by General Electric not to attempt operation of their Midwest Fuel Recovery Plant.[4]

Therefore, it is useful to look at the costs as they are being developed and projected for the interim storage and disposal and determine what costs might develop for the back end operations in the event of some low probability circumstances. The technique to evaluate these effects is to hypothesize different events or scenarios and then redo the cash flow and cash revenue situation to develop a new charge. There are several apparent alternatives dealing with different growth, schedules and unit costs which could be considered normal projective variations. A review of these conditions in the previous perturbations demonstrated that these differences are not likely to affect the overall economics of nuclear power substantially.

Of more concern would be a low probability event such as a major change in disposal operation or facilities at about the time when a significant fraction of the monies had already been invested in a reference design case. Although there can be any number of hypothetical "accident" scenarios, the following was assumed as representative of a serious back end problem in order to evaluate the cost effects. About the time the disposal facility is to start operation, it is assumed that that facility is not satisfactory. This hypothesis then creates a storage problem so that additional ISFS capacity would be required to handle the fuel that would otherwise be going to the repository. It is further assumed that a new repository is built which satisfies the problem identified on the first. A hypothetical back end system is assumed: including the additional ISFS and both the useable and unuseable repository. Revised pricing of the fee is developed assuming that all fuel received after the decision point not to use the first facility must pay for all costs incurred. The following table summarizes these costs as compared to the nominal reference $114/kgU while the storage and disposal costs actually decline from the reference $202/kgU due to opportunities to optimize the construction and operation of the ISFS basins.

"CONTINGENCY" CASE ($/kg)

	Disposal Only	Storage and Disposal
ISFS	—	44
Transporation	—	20
Encapsulation	27	22
Failed Repository	44	35
Geologic Repository	34	27
R&D and Government Overhead	32	32
Total	137	180

One other point that is useful to consider and separates this back end investment situation from those others which result in very high monetary losses is that a product "high level waste" is continually building in inventory and that inventory will have to be disposed of. Even a moratorium on operation of existing nuclear power plants sometime in the future would still require a very substantial repository capability to deal with the inventory currently in place and being expanded.

B.7.2 Return of Fuel/Credit

The fee structure discussed in this Volume has been predicated on the assumption that spent reactor fuel represents a waste material, the management and ultimate disposal of which is the responsibility of the Federal Government.

Conceptually, the spent fuel discharged from individual power reactors is required to be cooled for a minimum of five years before the U.S. Government will accept it for waste management purposes; presumably, this five years of cooling will be accomplished in spent fuel storage facilities on the reactor site. At the option of the utility and upon prior notice to the U.S. Government, utilities could then ship the spent fuel, at the utilities' expense for such shipment, to the Government. Such shipment could either be to an ISFS for interim storage and eventual transfer to a repository or directly to the geologic repository for permanent disposal.

While structuring of the fee does not contemplate any fuel cycle mode of operation other than once-through, this structure does not prevent a change in policy at some time in the future. The Department of Energy has indicated this possibility in their policy statement.

> "If, at some time in the future, the U.S. should decide that commercial reprocessing or other energy recovery methods for spent fuel can be accomplished economically and without serious proliferation risks, the spent fuel could either be returned with an appropriate storage charge refund, or compensation could be provided for the net fuel value."

It should be noted that the policy statement on receipt of fuel by the Federal Government for interim storage and subsequent disposal does not commit return of such fuel if reprocessing and recycle came into being, nor conversely does the policy prohibit such return of fuel provided the technology, environmental effects and costs developed are found to be desirable and have a positive cost/benefit effect. The return of fuel for recycle and reprocessing involves a whole different series of environmental effects which would be addressed in a separate NEPA review if such a change in U.S. Government policy were to occur.

In regard to the fees collected by the U.S. Government it is clear that they will have been established to adequately provide monies for the continued "storage of fuel". At any point in time, when an alternative cycle could be considered, the costs that are involved for such an alternative cycle, including for example the recovery of fuel already sent to disposal, can be incrementally analyzed. These costs can be compared to the funds that are available for future storage as well as the current revenues being received to determine whether there would be a credit or a cost for such return of fuel. In other words, at any point in time, even assuming a change in policy, the continued costs to the U.S. Government can be based on a "full cost recovery" principle. The cost associated with such return of fuel may be considered, and each utility can decide, based on the costs and benefits of such a return, whether or not to elect for return.

It appears that the fee structure contemplated is capable of dealing not only with the perturbations of the storage/disposal scenario but has sufficient flexibility to deal with even such a substantive change in policy as a reprocessing/recycle mode. This does not appear to compromise the "full cost recovery" principle.

C. UTILITY VIEW OF FEE

The utility has several views or uses which will be made of a spent fuel storage and disposal fee. First, as discussed earlier in Section II, the level of the fee per se could have an influence on a nuclear decision versus an alternative form of generation of power but with the fee at the full cost recovery level this is a fairly negligible consideration. Second, with the utilization of a use-based fee (that is, storage and disposal and disposal only) as the two charges the utility has the capability of optimizing the storage function with an overall cost benefit as well as an environmental effects benefit (See Section IV.A.2).

The last concern is that of the recovery of the charge from the consumers of electricity and the procedures for accomplishing this are somewhat different depending on the time of payment of the fee and, further, the calculated net fuel cycle cost is also different dependent upon this payment time. By way of illustration, in the base case the storage and disposal charge is \$202/kgU and this can be equated to a directly allocated cost of 0.81 mills/kWh (electrical conversion efficiency of 34% and an average burnup of 31,000 MWD/metric ton of uranium). Assuming an annual fixed charge rate applicable to the nuclear fuel investment of 16%/yr, Table III B.3 relates the base which is paid at the time of transfer to the U.S. Government to other payment times both in terms of direct cost and the fuel cycle cost which considers both the direct charges and the carrying charges associated with the cost and its payment time.

The utility would view any of the three alternatives above as a "one-time-charge" and could account for it appropriately in their normal fuel accrual and fuel expense recovery procedures. In this case there is perfect foresight regarding the payments and hence there is no need for any corrective action in any of the values. In an escalation situation the fee paid in \$/kgU would vary substantially over a 10 year time frame used in the above table. The earlier the payment to the U.S. Government the more difficulty the Government will have in recovering those later costs which are actual costs which are more escalated. Further, development of the cost (even without escalation) on a very early payment structure would not have the benefit of the history of actual facility construction and related costs as input to the computation and hence would be subject to substantially greater errors than say a payment at the time of transfer. For payments at the time of transfer the utility could in fact make projection analyses of escalation or trends of the charge so that they could appropriately collect revenues during the power generation period to reasonably approximate the final charge. There is, in fact, provision in the normal FERC accounting procedures used when recycle fuel was the standard mode of operation in which an adjustment either plus or minus in the value of residual fuel could be made when that value was known -as long as this charge resulted in a relatively modest variation from that which was projected and presented no real fuel cycle costing problem.

On the other hand, in an escalating economy if the fee were paid 8 years prior to the transfer of fuel (say 1978 payment for 1986 transfer) \$202/kgU paid in 1978 would have risen to \$299/kgU in 1986. This comparison showing the potential impact of escalation is intended to be illustrative only. The mechanism for factoring in inflation effects to the fee has not yet been finalized and assumptions have been made in this example regarding both the payment mechanism and the escalation rates. The \$299/kgU figure assumes an increase in the Gross National Product Implicit Price Deflator (GNP Deflator) of 7%/year in 1978 and 1979, 6%/year in 1980, 5%/year in 1981 and 4%/year from 1982 on.

D. SUMMARY

Table III.D.1 summarizes the reference fees and perturbations discussed in this Section. As has been noted in the discussion in Sections III.A and III.B, the larger the spent fuel flows, the lower the fee per unit of fuel handled (although the timing of fuel transfers will alter the proportionality between the two).

Final facility design and installation will attempt to optimize capacities relative to the fuel flows to be handled. The low demand case, as here computed, evolves an unrealistically high value because the available costing data reflects significant excess ISFS capacity and would be substantially affected by optimization. Differences in financing methods for ISFS facilities would likely lie between the values developed in the reference fee and private ISFS cases and do not result in significantly different fees.

TABLE III.D.1

Comparison of Reference Fee and Perturbations ($/kgU)

Fuel Flows / Cost Component	Reference Domestic/ with Foreign	High/Low Demand	One Repository*	Repository Delayed 5 yrs.*	Levelized*	Private ISFS*	"Contingency"*
ISFS							
Disposal Only	--	--	--	--	11	--	--
Storage and Disposal	104/89	50/201	104	63		148	44
Transportation							
Disposal Only	--	--	--	--	3	--	--
Storage and Disposal	26/24	20/30	26	18		26	20
Encapsulation							
Disposal Only	34/33	30/58	34	34	32	34	27
Storage and Disposal	26/23	18/52	26	19		26	22
Geologic Repository							
Disposal Only	51/50	34/99	39	60	48	51	34
Storage and Disposal	39/35	20/88	30	33		39	27
Failed Repository							
("Contingency" Case Only)							44
Disposal Only							35
R&D and Gov't.Overhead							
Disposal Only	32/31	19/78	32	66	31	32	32
Storage and Disposal	32/31	19/78	32	66		32	32
Total							
Disposal Only	117/114	83/235	105	106	125	117	137
Storage and Disposal	227/202	127/449	218	199		271	180

*Based on Reference Fuel Flows including foreign fuel. The comparison is to $114/kgU for disposal only and $202/kgU for storage and disposal.

Major alterations in program schedule - on either a planned delay or "contingency" basis - have been evaluated and do not result in significant differences in the fee from that of the reference case.

In summary, evaluation of a range of possible differences in the development of the spent fuel storage and disposal program indicates that the resulting fee is likely to lie within a range of about $\pm$35% of the reference fee value. In terms of the related power costs this range is from 0.23 to 0.48 mills/kwhr for payment at time of transfer of fuel to the Government (5 years after discharge from the facility).

References for Section III

1. Preliminary Estimates of the Charge for Spent Fuel Storage and Disposal Services, U.S. Department of Energy Report, DOE/ET-0055, Washington, DC, (July 1978).

2. Ibid.

3. Op Cit (1), pp. 20-23.

4. In a July 1974 letter to AEC, GE's Nuclear Division Counsel, Robert Lowenstein, stated that a conclusion had been reached that the existing plant would not work for technical reasons. The company estimated that an additional 4 years and 90 to 130 million dollars would have to be spent redesigning and rebuilding the facility which already had cost 64 million dollars. (Nuclear Industry, Vol. 21, No. 7, July 1974, p. 8).

IV. ENVIRONMENTAL EFFECTS

The environmental effects due to management of spent fuel in accordance with the Spent Fuel Policy announced by the Department of Energy in October 1977 have been analyzed and discussed in Volumes 2 and 3 of this EIS. This Volume of the EIS analyzes the relationship between the fee levied by the U.S. Government for spent fuel storage and disposal services (considering level, structure and payment alternatives) and the environmental effects of the program.

13-w Different fuel flows were used in establishing the illustrative fees in Section III and evaluating the environmental effects in this section to provide a conservative assessment in each case. A lower estimate of fuel flows was used to establish fee parameters to give the maximum economic effect. A higher estimate of fuel flows was used to determine the environmental effects.

c As discussed in Section I (p.I-2) DOE proposes the Spent Fuel Policy be implemented and that a fee be levied to recover all costs to the Government of providing the storage and/or disposal services required to implement this Policy. The environmental effects of this proposed fee and alternatives are discussed in this section. The fee structures which were analyzed include non-implementation of the spent fuel policy, a "levelized" fee with a single charge levied regardless of services rendered, the reference fee which is based on a use-base charge that relates the fee to the services required (interim storage followed by disposal or disposal only), a fee similar to the reference fee but modified to provide payment to the Government at other than the time of fuel transfer, a fee developed on a basis other than full-cost-recovery, a fee involving non-one-time payment, and the effects on the fee of various options for financing interim storage, and an alternative fee structure for foreign fuel.

13-e The analysis includes a comparison of the relative environmental costs of these alternatives and a discussion of the benefits resulting from assessment of a fee on the different bases considered. Because of the important qualitative considerations involved, for example, in the area of nonproliferation benefits, this analysis has not been reduced to a strictly monetary cost/benefit comparison.

A. Alternative Pricing Methodologies

c A range of environmental impacts based on different fuel flows likely to result from alternative fee structures has been evaluated and is described in this section. The cases analyzed are:

- Non-Implementation of Spent Fuel Policy (Case A)—Compatible with Alternative 2B of Volume 2 for domestic fuel and Case A of Volume 3 for foreign fuel.
- Use-Based Methodology (Case B)—Reference Fee Case—Compatible with Alternative 1B2 for domestic fuel and Case D for foreign fuel.
- "Levelized" Fee Methodology (Case C)—Compatible with Alternative 1B-1 for domestic fuel and Case D for foreign fuel.

The probable effects on these cases of different fee payment times, other than full-cost recovery basis and non-one-time payment, ISFS financing alternatives, and an alternative fee for foreign fuel are subsequently discussed. Although not strictly a fee-related issue, the case of non-implementation of the c spent fuel policy is included for completeness. The at-reactor basin (ARB) storage (Alternative 2B of Volume 2) was chosen to characterize this alternative to highlight the result that environmental impacts due to increasing onsite storage capacity are highest when additional storage capacity is constructed and lowest when maximum use is made of existing reactor discharge basin capacity. Effects due to storage at a single ISFS (Case C) are bracketed by these alternatives.

The environmental effects associated with domestic fuel result solely from interim storage activities on the premise that disposal impact will be incurred whether or not the Spent Fuel Storage policy is implemented. Use of Case D to characterize the impact of acceptance of foreign fuel assumes that this fuel will be disposed of in the U.S. Environmental effects attributed to foreign fuel therefore, reflect both interim storage and disposal in a geologic repository.

A.1 <u>Non-Implementation of Spent Fuel Policy (Case A)</u>

Under this alternative no U.S. Government storage services are provided. In the absence of such services, the remaining options available to the utilities are: 1) densification of existing reactor pools; 2) expansion of reactor pools currently under construction or planned; 3) construction of new at-reactor basins; or 4) transportation to private ISFS facilities.

c For comparison purposes the at-reactor basin (ARB) storage option was chosen as the non implementation case. It is assumed that no foreign fuel is shipped to the U.S. The material flows which are expected under this scenario are as shown on Table IV-1 and Table IV-2. (The flows analyzed in this section are
13-w taken from Volumes 2 and 3 of this EIS. They differ from the reference case evaluated in Section III but Case C—Centralized Storage—is the same as the High Flow Perturbation of that section.

The environmental impacts of non-implementation of the Spent Fuel Policy assuming use of the ARB storage option have been analyzed as Alternative 2B in Volume 2 and Case A in Volume 3 and are shown in Table IV-3 and Table IV-4.

A.2 <u>Use-Based Methodology (Case B)</u>

This fee structure is based on charging each customer for the services it uses. There are separate charges for storage and disposal customers and for disposal only customers. This fee structure which is based on a one-time charge and full cost recovery (as are all alternatives unless otherwise specified) is considered the reference fee for purposes of analysis.

c It is important to note that the analysis of the impacts of the options available to domestic utilities with this pricing structure does not include disposal. This is because all domestic spent fuel, unless it is reprocessed, will ultimately require disposal at a U.S. Government facility. Therefore, no disposal impacts are
c calculated resulting from domestic participation in the program. For foreign fuel, however, Case D of Volume 3 has been used. This provides for iterim storage and geologic disposal of foreign fuel in the U.S.

TABLE IV-1

Spent Fuel Movement - Decentralized Storage in At-Reactor Basins - Policy not Implemented

(No ISFS's, No Shipments of Foreign Fuel) 1985 Startup of Disposition Facility

Case A

	At Reactor Basin Fuel Shipments, MTU		Inventory, MTU	Disposition Facility Fuel Shipments, MTU		Inventory, MTU	Transshipment Between Reactor Basins, MTU
	Reactor to ARB	ARB to Disposition Facility		Reactor to Disposition Facility	ARB to Disposition Facility		
1978	-	-	0	-	-	0	109
1979	-	-	0	-	-	0	86
1980	-	-	0	-	-	0	129
1981	-	-	0	-	-	0	154
1982	-	-	0	-	-	0	172
1983	1160	-	1160	-	-	0	-
1984	1518	-	2678	-	-	0	-
1985	1571	-	4249	100	-	100	-
1986	469	-	4718	1600	-	1700	-
1987	715	-	5433	1600	-	3300	-
1988	-	-	5433	3155	-	6455	-
1989	-	1408	4025	3368	1408	11231	-
1990	-	1292	2733	3760	1292	16283	-
1991	-	962	1771	4268	962	21513	-
1992	-	751	1020	4453	751	26717	-
1993	-	672	348	4776	672	32165	-
1994	-	348	-	5026	348	37539	-
1995	-		-	5481	-	43020	-
1996	-		-	5478	-	48498	-
1997	-		-	5505	-	54003	-
1998	-		-	5965	-	59968	-
1999	-	-	-	6018	-	65986	-
2000	-	-	-	6406	-	72392	-

Source: Table III-14, Volume 2.

TABLE IV-2

Spent Fuel Movement - Decentralized Storage in At-Reactor Basins - Policy Not Implemented
(No ISFS's, No Shipments of Foreign Fuel) 1995 Startup of Disposition Facility

Case A

	At Reactor Basin Fuel Shipments, MTU		Inventory, MTU	Disposition Facility Fuel Shipments, MTU		Inventory, MTU	Transshipment Between Reactor Basins, MTU
Year	Reactor to ARB	ARB to Disposition Facility		Reactor to Disposition Facility	ARB to Disposition Facility		
1978	-	-	-	-	-	-	109
1979	-	-	-	-	-	-	86
1980	-	-	-	-	-	-	129
1981	-	-	-	-	-	-	154
1982	-	-	-	-	-	-	172
1983	1,160	-	1,160	-	-	-	-
1984	1,518	-	2,678	-	-	-	-
1985	1,671	-	4,344	-	-	-	-
1986	2,069	-	6,418	-	-	-	-
1987	2,315	-	8,733	-	-	-	-
1988	3,155	-	11,888	-	-	-	-
1989	3,368	-	15,256	-	-	-	-
1990	3,760	-	19,016	-	-	-	-
1991	4,268	-	23,284	-	-	-	-
1992	4,453	-	27,737	-	-	-	-
1993	4,776	-	32,513	-	-	-	-
1994	5,026	-	37,539	-	-	-	-
1995	5,381	-	42,920	100	-	100	-
1996	3,878	-	46,798	1,600	-	1,700	-
1997	3,905	-	50,703	1,600	-	3,300	-
1998	1,765	-	52,468	4,200	-	7,500	-
1999	-	880	51,588	6,018	880	14,398	-
2000	-	1,000	50,588	6,406	1,000	21,804	-

Source: Table III-15, Volume 2.

TABLE IV-3

Comparison of Major Environmental Impacts of the Fee to be Charged for Storage and Disposal of Spent Power Reactor Fuel with 1985 Repository

EFFECTS	CASE A U.S.(1)	CASE A Foreign(2)	CASE B U.S.(1)	CASE B Foreign(2)	Case C U.S.(1)	Case C Foreign(2)
Land Use, Acres						
Surface	0	0	1000	27	1000	27
Materials						
Concrete, m^3	$3.0x10^5$	0	$6.7x10^3$	$1.8x10^4$	$2.3x10^4$	$1.8x10^4$
Lumber, m^3	$1.8x10^4$	0	$3.9x10^2$	$7.7x10^2$	$1.3x10^3$	$7.7x10^2$
Steel[a], tonne	$1.5x10^5$	0	$6.1x10^3$	$2.5x10^4$	$2.1x10^4$	$2.5x10^4$
Copper[a], tonne	$4.3x10^2$	0	$9.5x10^0$	3.2x10	3.2x10	3.2x10
Zinc[a], tonne	$7.2x10^2$	0	$1.6x10^1$	2.4x10	5.4x10	2.4x10
Lead[a], tonne	$8.8x10^3$	0	$8.8x10^3$	0	$8.6x10^2$	0
Depleted Uranium[a], tonne	$4.9x10^2$	0	$4.9x10^2$	0	$4.9x10^2$	0
Chromium[a] (in stainless steel), tonne	$3.7x10^3$	0	$6.0x10^2$	$3.1x10^2$	$1.3x10^3$	$3.1x10^2$
Nickel[a] (in stainless steel), tonne	$1.6x10^3$	0	$2.6x10^2$	$1.4x10^2$	$5.8x10^2$	$1.4x10^2$
Energy						
Propane, m^3	$7.7x10^3$	0	$1.7x10^2$	$3.3x10^2$	$5.9x10^2$	$3.3x10^2$
Diesel Fuel, m^3	$3.1x10^5$	0	$1.7x10^5$	$2.7x10^5$	$1.7x10^5$	$2.7x10^5$
Gasoline, m^3	$1.4x10^5$	0	$3.0x10^3$	$4.6x10^3$	$1.0x10^4$	$4.6x10^3$
Electricity, MW-yr	$1.8x10^2$	0	$8.2x10^0$	8.9x10	6.5x10	8.9x10
Coal, tonne	$1.2x10^6$	0	$5.4x10^4$	$3.4x10^5$	$4.0x10^5$	$3.4x10^5$
Manpower, man-hour	$1.1x10^8$	0	$3.9x10^7$	$1.1x10^7$	$4.5x10^7$	$1.1x10^7$
Radiation Dose Commitment, man-rem[b]						
Population	$4x10^3$	$5.5x10^3$	$3x10^2$	$8.5x10^2$	$1x10^3$	$8.5x10^2$
Work Force	$6x10^3$	0	$8x10^2$	$7.1x10^2$	$1x10^3$	$7.1x10^2$
Health Effects[c]						
Population	2	N.A.	1	N.A.	1	N.A.
Work Force	4	N.A.	1	N.A.	1	N.A.
	6	3.2	2	1.0	2	1.0
Occupational Accidents (nonradiological fatalities)	23	0	11	3.4	11	3.4

NOTES: (1) From Tables V-2 and VIII-1, Volume 2
(2) From Tables VI-1, VI-2, and VIII-1, Case D, Volume 3
N.A. - Not available

a) A significant fraction of these materials could be recovered during decommissioning of facilities and recycled, if desired.

b) Whole body dose during the operating period plus the next 100 years. (For comparison, the equivalent dose to the world population from natural radiation sources over the same period is about $2x10^{11}$ man-rem. This natural dose would result in 120 million health effects). Exposure is to the worldwide population for domestic fuel and to the population in the U.S. & Global Commons for foreign fuel.

c) Serious genetic and somatic health effects were calculated from radiation doses assuming a linear dose-health effect relation. EPA dose-effect factors were used.

TABLE IV-4

Comparison of Major Environmental Impacts of the Fee to be Charged for Storage and Disposal of Spent Power Reactor Fuel with 1995 Repository

	EFFECTS	Case A		Case B		Case C	
		U.S. (1)	Foreign (2)	U.S. (1)	Foreign (2)	U.S. (1)	Foreign (2)
	Land Use, Acres						
	Surface	0	N.A.	4000	27	3000	27
	Materials						
	Concrete, m^3	$6.5x10^5$	0	$7.1x10^4$	$3.6x10^4$	$1.2x10^5$	$3.6x10^4$
	Lumber, m^3	$3.7x10^4$	0	$4.0x10^3$	$1.6x10^3$	$6.0x10^3$	$1.6x10^3$
	Steel, tonne	$3.4x10^5$	0	$5.8x10^4$	$4.4x10^4$	$1.1x10^5$	$4.4x10^4$
	Copper[a], tonne	$8.9x10^2$	0	9.7x10	5.1x10	$1.5x10^2$	5.1x10
	Zinc[a], tonne	$1.5x10^3$	0	$1.6x10^2$	5.7x10	$2.5x10^2$	5.7x10
	Lead[a], tonne	$1.2x10^4$	0	$9.6x10^3$	0	$1.1x10^4$	0
	Depleted Uranium[a], tonne	$6.5x10^2$	0	$5.5x10^2$	0	$6.9x10^2$	0
	Chromium[a] (in stainless steel), tonne	$1.0x10^4$	0	$3.7x10^3$	$1.2x10^3$	$5.4x10^3$	$1.2x10^3$
	Nickel (in stainless steel), tonne	$4.5x10^3$	0	$1.7x10^3$	$5.2x10^2$	$2.4x10^3$	$5.2x10^2$
	Energy						
	Propane, m^3	$1.6x10^4$	0	$1.8x10^3$	$7.0x10^2$	$2.7x10^3$	$7.0x10^2$
	Diesel Fuel, m^3	$4.8x10^5$	0	$2.0x10^5$	$2.4x10^5$	$2.2x10^5$	$2.4x10^5$
	Gasoline, m	$2.8x10^5$	0	$3.0x10^4$	$1.1x10^4$	$4.7x10^4$	$1.1x10^4$
	Electricity, MW-yr	$1.4x10^3$	0	$5.0x10^2$	$2.5x10^2$	$1.0x10^3$	$2.5x10^2$
E	Coal, tonne	$7.6x10^6$	0	$3.0x10^6$	$1.3x10^6$	$6.2x10^6$	$1.3x10^6$
	Manpower, man-hour	$1.9x10^8$	0	$7.6x10^7$	$1.8x10^7$	$8.5x10^7$	$1.8x10^7$
	Radiation Dose Commitment, man-rem						
	Population[b]	$3x10^4$	N.A.	$9x10^3$	$3.0x10^3$	$2x10^4$	$3x10^3$
	Work Force	$3x10^4$	N.A.	$4x10^3$	$1.5x10^3$	$8x10^3$	$1.5x10^3$
E	**Health Effects[c]**						
	Population	13	N.A.	6	N.A.	10	N.A.
	Work Force	19	N.A.	3	N.A.	6	N.A.
		32	N.A.	9	2.8	16	2.8
7-j	**Occupational Accidents (Nonradiological Fatalities)**	42	N.A.	14	4.2	17	4.2

Notes: (1) From Tables V-2 and VIII-1, Reference 1.
(2) From Tables VI-1, VI-2 and VIII-1, Case D, Reference 2.
N.A. - Not available

C a) A significant fraction of these materials could be recovered during decommissioning of facilities and recycled, if desired.

b) Whole body dose during the operating period plus the next 100 years. (For comparison, the equivalent dose to the world population from natural radiation sources over the same period is about 2x10" man-rem. This natural dose will result in 120 million health effects.) Exposure is to the worldwide population for domestic fuel and to the population in the U.S. and Global Commons for foreign fuel.

c) Serious genetic and somatic health effects were calculated from radiation doses assuming a linear dose-health effect relation. EPA dose-effect factors were used.

Combining these parameters results in a sequence of spent fuel movements which may vary depending on assumptions made regarding the timing of both the spent fuel discharge and the storage and disposal facility availabilities. Tables IV-5 and Table IV-6 illustrate one possible range based on the reference spent fuel discharge and assuming availability of an ISFS facility in 1983 and a disposal facility between 1985 and 1995. The environmental effects are shown as Case B Tables IV-3 and Table IV-4.

Individual utility decisions on transfer of spent fuel to the Government for storage may be affected by operating philosophy concerning the desirability of maintaining full core discharge capability in the reactor spent fuel pool to minimize forced outage time. For purposes of describing comparative environmental effects Volume 2 contrasts demand schedules based on either a rigorous requirement to maintain full core discharge capability at each facility or alternatively, to maintain discharge capability (about 1/4 to 1/3 of the core). This change in reserve capacity criterion results in a much lower amount of spent fuel being transferred offsite-with correspondingly lower environmental impact. A similar effect can be achieved by utilizing nuclear poison storage racks in the onsite pools a practice which the utilities are in fact pursuing and which is encouraged by implementation of a use-based fee.

A.3 Levelized Fee Methodology (Case C)

As discussed in Sections III.B.3 and III.C., the economic effects of developing the fee based on single rather than multiple cost centers can be substantial to the utility considering alternative spent fuel management programs. Promulgation of an aggregated fee would very likely inhibit the expansion of at-reactor storage capacity since the reactor operator could decide not to incur the additional cost of providing his own capacity.

As there is no cost advantage to the utility to provide its own storage, this fee structure leads toward interim storage with maximum use of ISFS with the associated shipping requirements.

The domestic and foreign requirements representative of this storage alternative were developed in Volumes 2 and 3 and are shown on Table IV-7 and Table IV-8.

The environmental effects of a levelized fee are shown as Case C on Table IV-3 and Table IV-4. As mentioned previously these values correspond to Alternative 1B1 of Volume 2 for domestic fuel and Case D (Option 3) of Volume 3 for foreign fuel. A comparison between this Case and Case B based on the reference fee shows the exceedingly small range of effects that might be expected due to the fee.

The difference in flows and facilities (and related impacts) which might evolve due to a levelized or use-based fee can be illustrated qualitatively as shown in Figure IV-1. This relationship between fee structure and spent fuel flows is valid regardless of whether an operating criterion of full core reserve capacity or discharge capability is applied. Case A in this figure reflects this alternative fee

TABLE IV-5

Spent Fuel Movements - Use-Based Fee

1985 Startup of Disposition Facility

Case B

Year	ISFS Facility			Geologic Repository		
	Annual Shipments Domestic	Annual Shipments Foreign	Inventory	Annual Shipments Domestic	Annual Shipments Foreign	Inventory
1978	--	--	--	--	--	--
1979	--	--	--	--	--	--
1980	--	--	--	--	--	--
1981	--	--	--	--	--	--
1982	--	--	--	--	--	--
1983	56	541	1519	--	--	--
1984	146	417	2365	--	--	--
1985	261	443	3314	100	--	100
1986	--	620	4034	1600	--	1700
1987	--	540	4574	1600	--	3300
1988	--	--	4574	4200	440	7940
1989	--	--	4574	5000	480	13420
1990	--	--	4574	5976	530	19926
1991	263	(181)	3993	4431	781	25138
1992	200	(390)	3203	4653	1050	30841
1993	--	(700)	2103	4776	1450	37067
1994	--	(700)	1003	5026	1530	43623
1995	--	(590)	--	5481	1490	58594
1996	--	--	--	5478	970	57042
1997	--	--	--	5505	1080	63627
1998	--	--	--	5965	1170	70762
1999	--	--	--	6018	1260	78040
2000	--	--	--	6406	1350	85796

Source: Domestic shipments from Table III-4, Volume 2.

Foreign shipments from Table II-1, Option 3, Volume 3, and private communication

Table IV-6

Spent Fuel Movements - Use Based Fee

1995 Startup of Disposition Facility

Case B

Year	ISFS Facility Annual Shipments Domestic	ISFS Facility Annual Shipments Foreign	ISFS Facility Inventory	Geologic Repository Annual Shipments Domestic	Geologic Repository Annual Shipments Foreign	Geologic Repository Inventory
1978	--	--	--	--	--	--
1979	--	--	--	--	--	--
1980	--	--	--	--	--	--
1981	--	--	--	--	--	--
1982	--	--	--	--	--	--
1983	56	541	1519	--	--	--
1984	146	417	2365	--	--	--
1985	361	443	3314	--	--	--
1986	531	620	4359	--	--	--
1987	1002	540	5734	--	--	--
1988	1362	440	6872	--	--	--
1989	1585	480	8104	--	--	--
1990	1717	530	9484	--	--	--
1991	2006	600	11811	--	--	--
1992	2345	660	14271	--	--	--
1993	2523	750	21021	--	--	--
1994	2953	830	27851	--	--	--
1995	3088	900	34751	100	--	100
1996	1883	900	40051	1600	70	1770
1997	2413	700	45151	1600	380	3750
1998	--	--	46151	5000	1170	9920
1999	--	--	46151	6018	1260	17198
2000	--	--	46151[a]	6406	1350	28436[b]

Source: Domestic shipments from Table III-5, Volume 2.

Foreign shipments from Table II-1, Option 3, Volume 3 and private communication.

a. Shipped to the repository after year 2000.

b. An additional 27,500 MTU spent fuel in domestic reactor discharge basins shipped to the repository after the year 2000.

TABLE IV-7

Spent Fuel Movements - Levelized Fee

1985 Startup of Disposition Facility

Case C

Year	ISFS Facility Annual Shipments Domestic	ISFS Facility Annual Shipments Foreign	ISFS Facility Inventory	Geologic Repository Annual Shipments Domestic	Geologic Repository Annual Shipments Foreign	Geologic Repository Inventory
1978	--	--	--	--	--	--
1979	--	--	--	--	--	--
1980	--	--	--	--	--	--
1981	--	--	--	--	--	--
1982	--	--	--	--	--	--
1983	970	541	1511	--	--	--
1984	1580	417	3508	--	--	--
1985	1602	443	5553	100	--	100
1986	468	620	6641	1600	--	1700
1987	736	540	7917	1600	--	3300
1988	--	--	7917	3155	440	6895
1989	--	--	7917	3368	480	10743
1990	--	--	7917	3760	530	15033
1991	(530)	(181)	7206	4698	781	20512
1992	(1410)	(390)	5406	5863	1050	27425
1993	(1300)	(700)	3406	6076	1450	34951
1994	(1300)	(700)	1406	6326	1530	42807
1995	(816)	(590)	--	6297	1490	50594
1996	--	--	--	5478	970	57042
1997	--	--	--	5505	1080	63627
1998	--	--	--	5965	1170	70762
1999	--	--	--	6018	1260	78040
2000	--	--	--	6406	1350	85796

Domestic shipments from Table III-2, Volume 2.
Foreign shipments from Table II-1, Volume 3 and private communication.
Same flows as Table III.B.2--high case--for determining fee.

TABLE IV-8

Spent Fuel Movements - Levelized Fee
1995 Startup of Disposition Facility

Case C

Year	ISFS Facility Annual Shipments Domestic	ISFS Facility Annual Shipments Foreign	ISFS Facility Inventory	Geologic Repository Annual Shipments Domestic	Geologic Repository Annual Shipments Foreign	Geologic Repository Inventory
1978	--	--	--	--	--	--
1979	--	--	--	--	--	--
1980	--	--	--	--	--	--
1981	--	--	--	--	--	--
1982	--	--	--	--	--	--
1983	970	541	1511	--	--	--
1984	1580	417	3508	--	--	--
1985	1702	443	5753	--	--	--
1986	2068	620	8341	--	--	--
1987	2336	540	11217	--	--	--
1988	3155	440	14812	--	--	--
1989	3368	480	18660	--	--	--
1990	3760	530	22950	--	--	--
1991	4168	600	27718	--	--	--
1992	4453	660	32831	--	--	--
1993	4776	750	38357	--	--	--
1994	5026	830	44213	--	--	--
1995	5381	900	50494	100	--	100
1996	3878	900	55272	1600	70	1770
1997	3905	700	59877	1600	380	3750
1998	965	--	60482	5000	1170	9920
1999	--	--	60482	6018	1260	17198
2000	--	--	60482	6406	1350	24954

Source: Domestic shipments from Table III-3, Volume 2.
Foreign shipments from Table II-1, Volume 3 and private communications.

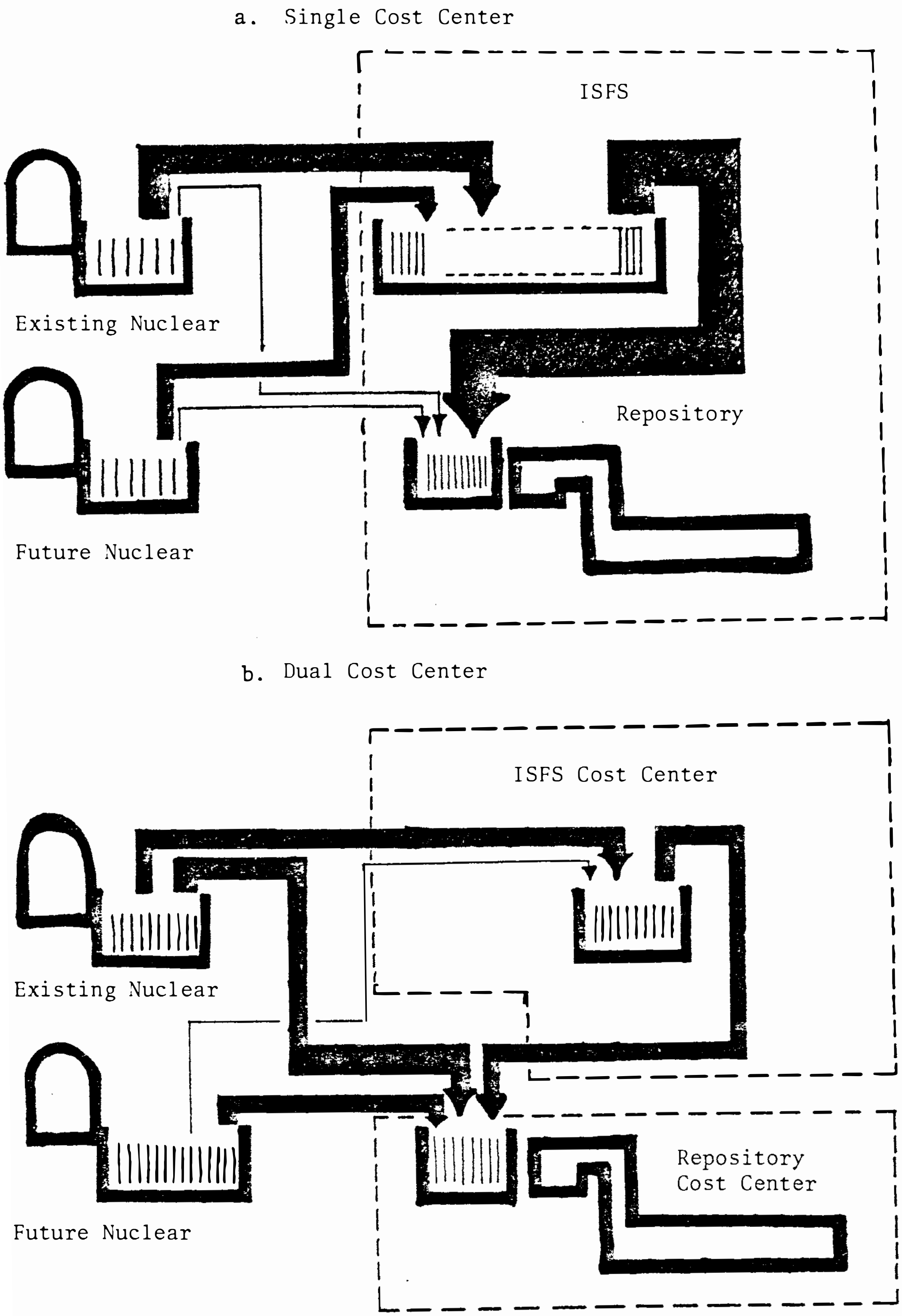

FIGURE IV-1 . Illustrative Fuel Flows as Related to Fee Cost Centers structure which groups together the ISFS interim storage, transportation to the geologic repository, encapsulation and burial as a "single cost center." The thickness of the "flow" lines between facilities gives a general indication of the relative amounts of spent fuel following various paths. In the case of existing reactors little further expansion of spent fuel storage capacity would be anticipated and most of the fuel would be transferred to ISFS and then retransferred to the repository as space becomes available. The situation with new reactors can also be expected to be biased toward the ISFS since this policy essentially provides emergency backup capacity which has to date been a utility responsibility.

In addition to the much higher transportation component from the ISFS to the repository it can also be noted from Figure IV-1 that the ISFS basin would be up to eight times larger than in the "Dual Cost Center" case. Case "b" in this figure, "Dual Cost Center," reflects the reference separated fee basis in which the charge is directly related to the services supplied to the utility. Spent fuel flow in this case shifts primarily to a "reactor to geologic repository mode" with a smaller fraction utilizing ISFS capacity. This is accomplished by maximum expansion of existing and planned reactor discharge basin spent fuel storage capacity which obviates the need for ISFS basins for many utilities. The prime impetus for this expansion is likely to be economic since it appears that in-plant storage of spent fuel is much less expensive than the same storage at an ISFS basin. Transportation costs overall would be expected to be smaller in this case not only from a mileage standpoint but also because it is necessary to load and unload most fuel only once, thus minimizing total cask use time and associated occupational exposure. The comparative economics of the alternative storage modes would vary from utility to utility depending on such factors as the potential for reactor discharge basin capacity increase, specific hardware used, company cash flow considerations, and timing of additional capacity needed. Therefore, the spent fuel storage alternatives representative of the use-based and "levelized" fees - and related environmental impacts - presented must be considered indicative of the effects of the different fee structures rather than definitive. Should additional capacity become necessary, it is entirely feasible for one or several utilities to build another pool or a major expansion of a pool at an existing site, thus taking advantage of previous licensing work, trained staff, etc. More detailed discussion of the impacts due to expanded at-reactor storage is included in Volume 2.

With regard to foreign fuel, factors other than the fee will more greatly influence foreign acceptance of the U.S. spent fuel storage offer. First, the U.S. offer is not open-ended. Each foreign request will be evaluated in terms of the benefit to U.S. non-proliferation objectives and a determination as to whether the country concerned has a real need for the service. More details on the definition of need and eligibility for acceptance appear in the discussion of options 1-3 in Volume 3. As noted there the United States assumes that other nations have responsibility for the resolution of their respective spent fuel storage problems.

Secondly, foreign nations will evaluate the U.S. offer in the light of their respective fuel cycle policies. Relevant factors include the ease or difficulty of selecting local storage sites in the light of domestic politics, geologic considerations and demographic considerations. The cost and availability of alternative disposal methods including domestic reprocessing or reprocessing in another country, or storage in a country other than the U.S. or in a multi-national center, will be considered. Some nations have long term plans for spent fuel storage, while others will not have sufficient lead time to make such facilities available.

Third, the attractiveness of the U.S. offer will be influenced by U.S. non-proliferation policy and the non-proliferation policies of other foreign states, including prospectively eligible countries and countries which might offer contract reprocessing services to others as an alternative to spent fuel storage in the United States. Some countries will accept the U.S. offer in order to support the U.S. position on the delay of reprocessing. Others will reject the U.S. offer because they disagree with U.S. policy in this area. Whatever consensus emerges from the International Nuclear Fuel Cycle Evaluation, INFCE, on the future development of the nuclear fuel cycle and prospective international institutional arrangements will influence national fuel cycle policies. It is not possible at this time to predict the impact of a still emerging international scenario on appropriate fuel cycle development and associated non-proliferation measures and obligations.

In order to obtain non-proliferation benefits, which are to some degree time-sensitive, this analysis assumes that shipments of foreign fuel will be made in a timely manner assuming the existence of a clear need for the U.S. service. Foreign fuel would be sent to the U.S. at the earliest possible date. For fuel ready for shipment before 1988 disposal only service is not a reasonably available alternative. Delay would undermine the non-proliferation gains to U.S. policy. Therefore, countries taking advantage of the spent fuel storage offer in the near-term will purchase storage and disposal services. Countries taking advantage of the offer in the medium term could purchase disposal-only services to the extent that such services are available.

In conclusion, although the fee structure could in theory influence the level of foreign participation the U.S. offer, the ranges of fees analyzed in this document are not expected to significantly affect participation. Other factors are more likely to be influential.

As noted in the discussion of options 1, 2 and 3 in Volume 3 many uncertainties exist concerning the actual quantities of spent fuel which may be returned. Option 3 represents the maximum probable case based on the conditions of the U.S. offer and projected foreign spent fuel discharges. These uncertainties will have more impact on returns than the fee structure. The United States will make decisions on the acceptance of foreign spent fuel on a case-by-case basis, taking into account the benefit to non-proliferation objectives and the existence of a need for the U.S. storage service. The conditions governing such determinations are discussed more fully in Volume 3. The U.S. offer is limited to such cases. A decision to ship fuel will be determined by national fuel cycle policies, national fuel cycle costs and the availability and costs of alternatives, including the U.S. storage/disposal offer. National spent fuel storage costs may vary quite widely depending on the size and type of program, local infrastructure, available lead times and other factors.

A.4 Fee Payment Time

Another alternative pricing structure would be a use-based methodology, similar to the reference case, that includes a pre-payment of the fee. The utility view of alternative fee payment times has been discussed in Section III.C. The effect of requiring pre-payment of the fee is to increase slightly the related power cost due to financing at the utility cost of money rather than that of the Government. It is likely to result in decreased utility participation in the early

(ISFS storage) portion of the program and in increase in reactor discharge basin storage capacity primarily because of cash flow considerations. Thus, a prepayment schedule could be expected to encourage development of a storage mode similar to that of Case B.

A.5 Other than Full-Cost-Recovery

There are several alternative philosophies as to how the charge can be established in concept and as discused in some detail in the text that follows. If spent fuel management and disposal services are considered as a service provided by the Government to a specific customer or customers, there is precedent for the fee being charged representing recovery of full cost to the Government. Under other circumstances, the Government can absorb certain costs so as to subsidize users of the service or, in fact, charge a fee which goes beyond the cost to the Government. There have been other circumstances and precedents, e.g., attempts to impose commercial pricing for enrichment services where the Government can charge a fee which goes beyond recovery of its full cost. In the discussion below on fee structures other than full cost recovery, a use-based methodology was assumed.

Development of the reference fee on the basis of full cost recovery implies that the Spent Fuel Policy would be neutral to the manner in which utilities decide to provide adequate generation capacity for their customers. It is recognized, however, that arguments may be made for encouraging or discouraging use of specific fuels for various reasons - such as the oil to coal conversion program for generating facilities to control the rate of growth of oil imports.

The level of the fee as it would be established based on other than full cost recovery assumptions could have some environmental impact on the storage phase of the Spent Fuel Policy. As a generality, commercial pricing, that is, using costs of money more representative of private sector investment than Government investment, would increase the number of utilities for whom maximum on-site storage was the most economic mode and would evolve essentially a storage mode similar to that resulting from Case B.

Such a storage mode is in any event likely on economic grounds. Beyond that the impact of commercial pricing is problemmatical, although it would seem most reasonable to expect it would drive utilities to go forward with their own ISFS's as required assuming them to be sited, designed and constructed for optimum economics. It is not clear that the environmental impact would be any different with privately financed ISFS's than with Government financed ISFS's. Commercial pricing of waste management service should not significantly affect the decisions of most utilities on nuclear power.

On the other hand, an argument might be made for subsidy pricing on the basis that the once-through fuel cycle has its roots in non-proliferation objectives and that therefore the beneficiaries of the services provided under the Spent Fuel Policy are the general public rather than the utilities and their ratepayers. Therefore, Government compensation to the utilities might be appropriate for the residual fuel value taken to further this national objective. Evolution of such a pricing basis would be likely to encourage utility participation in the program at an early date - with the result that flows would evolve similar to those of the storage mode under the "levelized" fee (Case C).

It has been concluded, therefore, that within the range considered in this evaluation, neither penalty nor subsidy pricing would result in environmental impacts significantly different from those already evaluated on the full-cost-recovery basis with different pricing structures. (Case B vs. Case C).

Because the variation in fuel costs of alternate generation sources (to nuclear power) is about an order of magnitude larger than the reference fee, the comparative economics of the various sources is very insensitive to a change in fee. Therefore, imposition of a fee based on a philosophy of subsidy or penalty for nuclear generated electricity is not likely to result in any significant change in the rate of nuclear power growth and related amounts of fuel requiring storage and disposal from that of the reference case.

A.6 Non-One-Time Payment

A further option available to the Goverment is to structure a fee which includes provision for recovering unanticipated - or underestimated - costs subsequent to the time of transfer of the fuel and payment. This "back charge" provision may introduce some uncertainty into the utility accounting procedures that, as described in Section III.B.4.3 and III.B.7.1, even under extreme contingency conditions would not be likely to result in a fee that would affect the rate of growth of nuclear power significantly. Any uncertainty that may be created would tend to discourage participation in the program and increase reactor discharge
c basin storage. This discussion assumes a use-based charge similar to the reference case.

A.7 ISFS Financing Alternatives

Options for treatment of funds received are:

- o Application to the DOE budget as an offsetting revenue for all DOE activities (status quo):
- o Establishment of a separate trust fund, or its equivalent, under DOE management for waste disposal expenses only; or
- o Payment directly to the United States Treasury.[1]

The effect of these financing alternatives would probably result in no change to the level of participation and, therefore, to environmental impacts of the reference case.

A.8 Alternative Fee for Foreign Fuel

As proposed, the U.S. would only accept foreign spent fuel when this would be in the U.S.'S nonproliferation interest. In order to obtain control of this fuel, however, it may be necessary for the U.S. to provide incentives, including subsidizing the foreign fuel storage. A range of subsidies may be considered.

In order to induce the return of spent fuel under the policy, the United States
12-p could set a storage fee below full cost recovery. This policy could increase returns
13-j of spent fuel to the U.S. relative to the level expected with full cost recovery if it offset to some degree any disincentive to accepting the U.S. offer posed by the

logistical problems and costs of transporting material to the United States (a cost which must be borne independently of the fee as now proposed). To the degree to which a lower fee would have such an offsetting impact, it would help to induce returns up to the option 3 spent fuel schedule shown on Table III.a.3. High levels of return (Option 3) would result in nonproliferation benefits and other environmental impacts as described in Volume 3 for implementation of the Spent Fuel Policy with Option 3 fuel.

However, this approach would also pose a number of problems. First, not all
12-p potentially eligible nations would be influenced by a relatively minor subsidy in
13-j making decisions about participation in the U.S. offer. Management of the back end of the fuel cycle involves major, long term decisions with large finanacial and technical implications. In practice, as noted in Volume 3, the United States would establish conditions for participation which would require shipping countries to make good faith efforts to establish multinational, or where prudent, national spent fuel storage capacity. The financial commitments involved in such efforts would outweigh the value of a subsidy. The U.S. storage offer would be attractive to countries facing short or medium-term storage problems which could be eased by shipping spent fuel to the United States or by shipping fuel to a third country for reprocessing services. Second, for countries with smaller nuclear power programs subsidized spent fuel returns to the United States could constitute a disincentive to work toward more permanent long term solutions to the spent fuel problem. In such countries back end costs would be lower and hence the fee for the U.S. program could be more influential.

From the perspective of non-proliferation policy the United States has maintained that it will not ask foreign nations to make decisions in their respective nuclear power programs that it would not make in its own program. Equality of treatment for foreign and domestic users of a US storage program is an element in this policy of equal decisions of equal impact for supplier and consumer states involved in the development of nuclear energy for peaceful purposes. A subsidy could be interpreted abroad as a US attempt to thwart in a discriminatory manner foreign reprocessing activities instead of a cooperative venture designed to assist the international community at large in moving to avoidance of early reprocessing in the general interest of non-proliferation. A subsidy would also thwart US efforts to demonstrate the economic feasibility of long term spent fuel storage on a national or multinational basis. Offering a subsidy for spent fuel returns only to some nations would only enhance the potentially discriminatory image of such a fee structure.

From the operational point of view a subsidized fee for foreign users of a US ISFS program might present the appearance or fact that domestic users would be forced to make up the difference. Furthermore, the cost to the US Government of such a fee could be large, particularly when compared to the few benefits it is likely to achieve. Therefore, the reference fee has been based on assessing the same fee regardless of country of origin.

B. Safeguards

The transportation and storage activities described in this Volume involve radioactive and fissionable material which can, under specific circumstances, be misued to create an unacceptable public risk. Risk in the context of the Safeguard Section is the combination of the probability of a threatening act being attempted, the probability of the act being successful, and the probability that it presents hazard to the public. Examples of situations which migh represent such circumstances and the resulting risk to the public are described in Section IV of the Volumes 2 and 3 of this EIS.

C. Unavoidable Adverse Effects

Unavoidable adverse effects - radiological health effects, potential accidents and other - are described in Section V of Volumes 2 and 3 of this EIS and summarized on Table IV-3 and IV-4 for alternative pricing structures. Neither the radiological health effects to the worldwide population or the work force nor permanent land commitment, water and energy requirements and chemical discharges vary significantly due to fee-related considerations.

D. Irreversible And Irretrievable Commitment Of Resources

Resources that are committed in an irreversible and irretrievable manner by the proposed alternative actions consist of:

- Land areas permanently affected.
- Manpower for construction, operation and decommissioning of storage facilities, reprocessing plants, and transportation equipment.
- Materials such as fuels and chemicals consumed and construction materials that are not recyclable.

c Estimates of the principal resource commitments are discussed in Section VI of Volumes 2 and 3 of this EIS. There is no difference in the amount of land permanently committed (surface and subsurface) for the fee related storage alternatives.

E. Local Short-Term Uses of Environment as Related to Long-Term Productivity

The relationship between short-term environmental effects - generally land use and radiological impacts occurring during the construction and operational phases of the facilities - and long-term productivity - in terms of conservation of resources and allowable land use for the period extending beyond facility operation into the indefinite future - for various options influenced by the fee are discussed in Section VII of Volumes 2 and 3 of this EIS. The general conclusion of these analyses is that the differences in resource use between alternatives are small and will not preclude future options except to the extent to which resources are consumed. Resource consumption is a very small part of available resources. Use of small amounts of surface and subsurface land may be permanently restricted, primarily at the geologic repository with essentially no difference in the amount of land restricted whether or not the policy is implemented.

F. Environmental Tradeoff Analysis

The environmental tradeoff between implementing or not implementing the proposed Spent Fuel Policy with alternative storage modes has been analyzed and presented in Section VIII of Volumes 2 and 3 of this EIS. The tradeoff between alternative storage modes which might be influenced by the fee is described in this section.

The analysis in Section II.A.2.2 has shown that the anticipated effect of the fee at various projected levels under all reasonable alternatives (i.e., alternative cost center approaches, types of pricing methodologies, type of collection approaches) would have only negligible impact on utility decisions to construct nuclear power plants.

The tradeoffs of alternative fee methodologies are dependent upon the level of participation by both domestic and foreign customers. In terms of domestic customers, on economic grounds, the level of participation would be dependent upon the cost of the alternative (basin densification, construction of additional private pools, and transshipment to existing pools) and the substitution and competitiveness of the U.S. Government storage service.

The analysis of policy alternatives and related participation in the program - and environmental impact is as follows:

a. Reference Case (Use-based/full cost recovery/one-time charge) (Case B)

It is assumed that utilities can decide on reasonably available alternative actions, i.e.: 1) densification of existing reactor basins; 2) expansion of reactor basins currently under construction or planned; 3) construction of new at-reactor basins; or 4) transportation to private interim storage and disposal services as opposed to disposal services alone.

b. Nonimplementation Case (Case A)

For domestic customers, no participation in the U.S. Government program would tend to encourage either maximum use of existing basins or construction of private basins. As indicated in Volume 2, additional radiological health effects result from the longer period of operation of an ISFS and At-Reactor Basin (ARB) facilities, a larger work force, and a larger amount of fuel in storage. This alternative, moreover, assumes a total of 650 MTU transshipments during the period 1978 to 1983 as necessary shipments between existing reactor basins to prevent reactor shutdowns. Further, if those transshipments are not allowed, some reactors will be shut down (i.e., 4300 MWe of capacity) due to the lack of spent fuel storage capability.

In the absence of a U.S. Spent Fuel Storage Policy, there will be some transportation of spent fuel among countries either for storage or reprocessing of spent fuel. Transfers for reprocessing may involve return shipments of waste and separated plutonium or mixed oxide fuel. It is believed that shipment of plutonium or unirradiated MOX fuel is easier to divert and use for construction of illicit nuclear devices than irradiated spent fuel and would therefore create a greater proliferation risk. Accumulation of spent fuel at storage facilities also presents stocks of spent fuel that could be reprocessed to recover its contained plutonium.*

The precise amount of shipments of this kind will depend upon the fuel cycle policies and storage space available to nations which might have been eligible to benefit from the U.S. Spent Fuel Storage Policy.

c. "Levelized Fee" Case (Case C)

The degree of participation assumed is shown on Tables IV-7 and IV-8 (i.e., maximum centralized storage for domestic customers and participation by Option 3 countries for foreign customers).

For domestic customers, utilities could seek the economic advantage of utilizing Government-provided storage as well as disposal, or disposal only. Levelized fee assumes the fee will be calculated for all customers regardless of service provided. Thus, the economic incentives of utilities making provisions for their own services to the maximum extent possible, resulting from a use-based fee, are mitigated and, instead, Government-proved AFR storage is encouraged.

The aggregate environmental effects, as shown in Tables IV-3 and IV-4 are similar to the "Nonimplementation" and "Reference" cases. A comparison of these effects and those of the reference case would show a small but consistent environmental advantage for the use-based fee, as compared with a levelized fee, due primarily to additional transportation mileage and fuel handling involved in the alternative storage.

For foreign customers, it was shown in Tables IV-5 through IV-8 that no change occurs in practice for levels of participation between the "Levelized" and "Reference" cases.

13-a d. Other Methodologies

Implementation of the fee on other than the reference "one-time-charge" full cost recovery basis may lead to evolution of spent fuel flows and related environmental impacts which approximate either that expected from the "Use-Based" or "Levelized" fees discussed above (Cases B and C). For example providing the capability of assessing unanticipated cost changes to a specific batch of fuel subsequent to the time of transfer and/or payment (essentially a non-one time charge) increases the cost uncertainty faced by utilities in recovering the fee

*This summarizes the Nonproliferation considerations detailed in Volume 3. Case A.

13-a from their customers and results in some portion of the charge being collected after the operating period. This situation is contrary to utility regulatory policy and would be likely to result in less participation in the program. Fees assessed on other than a full cost recovery basis will tend to encourage participation if they are lower than full cost recovery and inhibit participation if they are higher than the full cost recovery level.

These general trends would be applicable both to domestic and foreign customers.

References for Section IV

1. "Preliminary Estimates of the Charge for Spent-Fuel Storage and Disposal Services", U.S. Department of Energy Report DOE/ET-0055, Washington, DC, (July 1978).

APPENDIX A - METHODOLOGY FOR DETERMINING FEE

The policy statement for interim storage of spent nuclear reactor fuel indicated the U.S. Government would take title to spent nuclear fuel from domestic utilities and some foreign countries on payment of a fee. The fee will cover the U.S. Government's full cost of providing either for interim storage and subsequent disposal or for disposal only of the spent fuel.

Facilities and services affected by the policy include:

1) ISFS (Independent Spent Fuel Storage) basins

2) Transportation from an ISFS to encapsulation and geologic repository facilities

3) Encapsulation facilities

4) Geologic repository facilities

5) Research and development and Government overhead

This appendix describes the methodology that will be used by the U.S. Government in determining the fees (one for diposal only, the other for storage and disposal) to be paid for the use of these facilities and services.

A fee for the storage and disposal of spent fuel from nuclear reactors, and a fee for disposal only, can be calculated by equating the values (at one common time) of all projected expenditures to all projected revenues. These two fees (unknown at the onset) multiplied by their respective annual amounts of fuel to be processed, provide the revenues for the equation. In addition to the annual schedules of spent fuel shipped directly from reactor to ISFSs and directly to the repository which are used in finding revenues, annual schedules of spent fuel transfer from the ISFS's to the repository are required. Annual schedules of expenditures must be developed for each component facility or service. Valuation at a common time is achieved by discounting or appreciating each payment to that common time from the year of receipt or disbursement, at the discount rate for government revenues, compounded annually, and summing the discounted (or appreciated) payments. For this purpose, all expenditures are assumed paid at the beginning of a year and all revenues received at the end of a year.

The time span selected for cost analysis is from the base year 1978 through the year 2000, with provision for including the impact of later costs. In the unescalated version, expenditures for all years are given in 1978 dollars and the two levelized fees calculated remain in force over the operational lifetime.

Government ownership and operation of the ISFS's, encapsulation, and geologic repository facilities are assumed. Arrangements for transportation, research, and development are treated as government operations. These assumptions are in line with Federal pricing policies. Should private ownership and operation of the ISFS basins be required, the slightly different methodology which would be required is available, but the major premise would remain unchanged.

Costs, including capital costs, for U.S. Government services (overhead, transportation, and research and development), for U.S. Government owned and operated facilities (encapsulation and geologic site facilities and ISFS basins) are all charged as expenditures when they occur and discounted, or appreciated, at the U.S. Government debt rate to the common valuation time. To offset capital costs charged for unused capacity of encapsulation and geologic sites facilities, a credit is included in the final year of the price calculations.

The credit is equal to the fraction of unused capacity times the original total capital cost of the facility.

For all facilities, two additional charges may be considered in the final year of operation: one for decommissioning and, optionally, one for surveillance. If the pricing period ends before the final year of facility operation, such charges (for encapsulation and geologic site facilities) are discounted back to the end of the pricing period and portions equal to the fraction of capacity used times the discounted charges are entered on the operating cost schedule in the end year.

Fees may be calculated on a single cost center basis or a multiple cost center basis (analagous to the "levelized" and "use-based" methodologies of DOE/ET - 0055). On a multiple cost center basis, customers may elect to avail themselves of disposal services only or storage and disposal services, and pay accordingly. With a single cost center, all users pay the same price for all facilities, whether they use them or not.

In calculating the single cost center fee, only the total annual amount of spent fuel to be delivered to the U.S. Government is used in finding the annual revenue. The revenue for any year equals the total amount of spent fuel received by the U.S. Government during the year times the (unkown) single cost center fee, which is assumed constant over the operational lifetime. Because the unknown fee is a constant, it can be factored algebraically from the total discounted revenues for all years, leaving as the one remaining factor the sum for all years of the discounted quantities of the spent fuel. Hence, the single cost center fee (or levelized charge or price) equals the quotient of the overall discounted cost total divided by the overall discounted fuel total; price components equal service or facility cost divided by the same denominator.

For the multiple cost center fee calculation, a stand-alone price is determined for each type of facility and service. A stand-alone price equals the total present value of expenditures for all facilities or services of the same type in the scenario under consideration, divided by the total present value of spent fuel flow through those facilities or services. The fee component for a user of a facility or service must equal the stand-alone price for that type of facility or service; or, if the fee must be paid prior to use of the facility or service, the fee component must equal the discounted value of that price. If a facility or service is not used, there is no fee component for it. The fee is the sum of the relevant component fees.

Disposal only users do not pay for ISFS basins or transportation therefrom. They pay the sum of:

1) The stand-alone price for encapsulation

2) The stand-alone price for repositories and

3) The overall price for research and development and U.S. government overhead.

Storage and disposal users pay a fee equal to the sum of:

1) The stand-alone price for ISFS basins

2) The discounted stand-alone price for transportation from ISFS basins to repositories

3) The discounted stand-alone price for encapsulation

4) The discounted stand-alone price for repositories

and 5) The overall price for research and development and U.S. Government overhead.

Details of the multiple cost center fee calculation follow:

The total present value of spent fuel entering ISFS's may be expressed -

$$Q_A = \sum_{t=m}^{t=n} \frac{Q_{At}}{(1+r)^t}$$

Where

t = year (with t=1 representing 1978)
m = first year of campaign
n = last year of campaign
r = discount rate
Q_{At} = the flow into ISFS's in year t
and Q_A = the total flow into ISFS's for all years of campaign.

Similarly, the total present value of spent fuel flowing directly into the repositories from disposal-services-only customers equals

$$Q_D = \sum_{t=m}^{t=n} \frac{Q_{Dt}}{(1+r)^t}$$

where

Q_{Dt} = the flow from reactors directly to repositories in year t and Q_D = the total flow from reactors direct to repositories for all years of the campaign.

Transfers from ISFS's to repository are assumed to take place at the end of the year of transfer to be consistent with the assumption of revenue receipt at the end of the year. The formula for these transfers is thus:

$$Q_T = \sum_{t=m}^{t=n} \frac{Q_{Tt}}{(1+r)^t}$$

where

Q_{Tt} = the flow out of ISFS's and into repositories in year t

and Q_T = the total flow from ISFS's to repositories for all years of the campaign.

From these three flows, Q_A, Q_D, and Q_T, the other required flows can be calculated. Thus Q, the overall flow for research and development and government overhead, equals - $Q = Q_A + Q_D$

And Q_R, the flow entering the encapsulation facilities and repositories, from both reactors and ISFS's equals - $Q_R = Q_D + Q_T$

The ratio Q_T/Q_A provides an average discount factor for the fee prepayment period which coincides with the average (for the particular campaign under consideration) residence time in the ISFS's.

Stand-alone prices are, in dollars per kilogram of uranium:
for the ISFS, $P_A = C_A / Q_A$

Where C_A = the sum of all discounted expenditures for all ISFS's; for transportation from ISFS's to repositories

$P_T = C_T / Q_T$

Where C_T = the sum of all discounted expenditures for transportation from ISFS's to repositories;

for encapsulation -

$P_E = C_E / Q_R$

where C_E = the sum of all discounted expenditures for all encapsulation facilities;

for geologic repositories - $P_R = C_R / Q_R$

where C_R = the sum of all discounted expenditures for all repositories;

and for research and development and government overhead -

$P = C_G/A$

where C_G = the sum of all discounted expenditures for research, development, and government overhead.

The total charge to disposal-services-only customers equals:

$$P_E + P_R + P_G.$$

For storage and disposal customers the total charge is:

$$P_A + P_G + (P_T + P_E + P_R)\, Q_T / Q_A$$

Where Q_T / Q_A is the average discount factor for the fee prepayment period.

The effect of cost escalation on price may be estimated using modified methodologies suitable to the two escalation models of interest:

1) The non-standard fuel escalation model in which expense or cost escalation to the year of payment is computed, and the standard model in which payment is computed only to expense or cost.

2) Cost escalation to the year of pricing.

For the first, the full escalation model, the only required modification is to calculate costs escalated to the year of expense payments. The resultant fully escalated expenditure schedule from the base year 1978 through the end of the scenarios, does not change from pricing year to pricing year. As a consequence of this invariance with time, the levelized price based on the expenditure schedule is constant for all pricing years.

In the second (standard) escalation model, costs are escalated only to the year of pricing. As the pricing year advances over the scenario time span, costs are further escalated. Thus the expenditure schedule (over the scenario time span) varies with pricing year, and the levelized price computed in any pricing year is generally different from that of the previous year.

It should be mentioned that in any calculation in which the pricing year is rolled forward, costs prior to the pricing year are represented by net cost accruals calculated in the pricing year in which revenue is received, and not further escalated or otherwise changed.

APPENDIX B - GLOSSARY OF TERMS AND ABBREVIATIONS

c

AFDC

Allowance for funds used during construction.

ARB

At-Reactor Basin

back-charge

assessment of additional charge subsequent to time of fee payment.

base-load capacity

That portion of a utility generating system which, because of favorable operating costs, is operated essentially full time.

BWR

Boiling Water Reactor

capital, fixed.

The total original cost of installed facilities which, in a commercial venture, cannot be deducted for tax purposes as a current expense in the year of acquisition; but for which depreciation is allowed by the tax authorities. Gross asset value, less land.

capital recovery.

The process by which original investment in a project is recovered over its life. Depreciation allowance provides for capital recovery in the absence of inflation.

capital, working.

The funds in addition to fixed capital, land investment, and startup expenses needed to get a project started and to meet subsequent expenses as they become due. Includes cash, receivables, and inventories, less payables.

capitalized cost.

The sum of money which, at a given interest rate, will provide an infinite series of payments of a desired amount without diminishing the original sum, or the system for replacement analysis employing that sum. Also, the depreciable portion of a fixed investment.

cash flow.

The passage of money into or out of the enterprise. For investment analysis, investments are usually considered as negative cash flows; after-tax profits and depreciation as positive cash flows.

cask

A container that provides sheilding and containment for the shipment or storage of radioactive material.

compaction.

Reduction in the spacing of racks that hold spent fuel in a water storage basin so that the basin can hold more fuel and still remain subcritical.

commercial pricing

Methodology for computing a price assuming a private entrepreneur provided the goods or services including such allowances as return on investments, taxes, etc.

contingencies.

An allowance for unforeseeable elements of cost, particularly in fixed investment estimates, which previous experience has shown to be statistically likely to occur.

cost center.

For accounting purposes, a grouping of items of equipment and facilities comprising a system or subsystem.

cost index.

See Inflation index.

depreciation.

An annual expense charge for recovery of fixed capital from an investment whose useful life is finite, but greater than one year.

discounting.

Use of compound interest to determine sums earlier in time equivalent to a later larger sum.

DOE.

U.S. Department of Energy.

dose commitment.

The amount of radiation to an individual or population over a stipulated period of time resulting from exposure to a given source.

dual cost center pricing

Methodology for computing spent fuel storage and/or disposal charge to allocate interim storage costs only to those customers using the service.

c <u>EIA</u>

Energy Information Administration

<u>EIS</u>.

Environmental Impact Statement (DEIS-Draft EIS; GEIS-Generic EIS).

<u>EPA</u>.

U.S. Environmental Protection Agency.

c <u>EPRI</u>

Electric Power Research Institute

<u>escalation</u>.

The provision in actual or estimated costs for an increase in the costs of equipment, material, labor, etc., over those specified in an original contract due to continuing inflation, etc.

<u>escrow funds</u>

Amounts restricted for a specific purpose by parties to an agreement. They are usually placed in the custody of a third party, frequently a trust company and are released only by the joint instructions of both parties to the contract.

<u>Federal repository</u>

See geologic repository

<u>FERC</u>

Federal Energy Regulatory Commission

<u>fixed costs</u>.

The costs which continue whether a facility is operated or not; essentially fixed in dollars per year independent of operating level. Includes property taxes, insurance, some maintenance, and depreciation (a non-cash expense) in all cases. Some labor may also be considered a fixed cost for many purposes as long as a facility is not shutdown.

<u>fuel assembly</u>

A grouping of fuel elements which is not taken apart during the charging and discharging of a reactor core.

fuel cycle.

The complete series of steps involved in suppling fuel for nuclear reactors. The cycle includes uranium mining and refining, uranium enrichment, fuel element fabrication, irradiation, chemical reprocessing (to recover the fissionable material remaining in the spent fuel), and disposal of radioactive waste. Later steps in the fuel cycle are re-enrichment of the enriched fuel material and refabrication into new fuel elements. In a once-through fuel cycle, spent fuel is not reprocessed to recover usable fuel; spent fuel is treated as waste.

c fuel element

The smallest structurally discrete part of a reactor assembly which has nuclear fuel as its principal constituent.

full cost recovery.

Includes charges to the user that compensate the Government for budgetary spending for capital and operating costs, return on invested capital, and costs to cover unusual hazards, e.g., insurance premiums, premium pay for hazardous work, workmen's compensation, etc.

c geologic repository

Geologic formation used as a site for storage or disposal of high level and transuranic waste.

GWD

A unit of energy production or consumption in a given day. One GW equals one billion watts or one thousand megawatts.

high-level radioactive waste

Liquid or solidified products of the chemical processing of irradiated fuel, and/or irradiated fuel elements if discarded without processing.

indirect expense.

(1) Fixed investment: engineering and construction expense, taxes, insurance, startup costs and contractors' fees which cannot be charged directly to cost centers. (2) Operating Costs: continuing expenses associated with facility operation but not directly assignable to process cost centers. Includes plant overheads and sometimes certain costs which might be considered direct expenses, but for which adequate cost records are unavailable.

inflation index.

A statistical time series which approximates the change in value of the dollar in a particular segment of the economy, usually based on an index of 100 for a given time. "Cost index".

c interest, compound.

The mathematical expression of the principle that money can be used to earn more money, and therefore that values can be assumed to grow with time at a certain rate. The rate (expressed as percent or decimal) at which a sum of money increases in value over each interval of time, usually one year.

interest rate of return.

The rate of compound interest at which an outstanding investment is repaid by proceeds of the project. Also the evaluation technique which judges the profitability of a proposed investment by this calculation.

investment tax credit

Reduction in Federal income tax up to a precentage of total investment as specified by law.

investor-owned utilities

Those utilities in which ultimate profit accrues to stockholders.

IOAA

Independent Offices Appropriations Act of 1952

IRG

Interagency Review Group

ISFS.

Independent Spent Fuel Storage Facility.

c kg

Kilogram(s)

kWh.

Kilowatt-hour, a unit of energy generation or consumption in a given hour.

c labor, operating.

That portion of labor cost which can be definitely assigned to one product or cost center. Usually excludes labor for maintenance, materials handling, and packaging.

"levelized" fee

Single fee for storage and/or disposal of spent fuel whether or not interim storage is required. Consistent with single cost center pricing.

LWR.

Light Water Cooled Power Reactor (BWR, PWR - types of LWR).

c maintenance.

The expense, for both labor and materials, required to keep a facility in a suitable operable condition. Maintenance excludes major items which are not expensed within the year purchased and thus must be considered fixed capital.

man-rem.

The total radiation dose commitment to a given population group; the sum of the individual doses received by a population segment.

MW-yr.

Megawatt-year, a unit of energy generation or consumption in a given year.

MTU.

Metric Tons of Uranium, (2200 pounds or 1000 kilograms).

mills/kWh.

Mills per kilowatt-hour, power cost per unit of energy generation.

NEPA.

National Environmental Policy Act of 1969.

c nonproliferation

Limits the number of nations capable of producing nuclear weapons

NRC.

Nuclear Regulatory Commission.

c one-time charge

Fixed charge not subject to subsequent adjustment.

operating cost.

The total costs chargeable to the furnishing of a service or product. Includes direct expenses such as supplies, labor, utilities, and also fixed or allocated charges such as maintenance, depreciation, insurance and property taxes. Overheads within the facility are usually considered as operating costs; administrative and research overheads and freight are not usually so included.

c

overhead.

Costs in a facility which are not directly assignable to any one product or processing cost center and therefore must be allocated on some arbitrary basis or else handled as a business expense independent of the portion of the facility capability utilized.

penalty pricing

Assessing a charge greater than that needed to recover full costs of providing facilities or services.

pool

A concrete chamber filled with water to provide shielding for irradiated fuel elements.

present worth (present value).

Current value of cash flow(s) as obtained by discounting. Also the investment-evaluation procedure which involves discounting at a specified interest rate (representing cost of capital or minimum acceptable return) to choose the alternative having the highest present value.

PWR

Pressurized Water Reactor

single cost center pricing

Methodology for computing spent fuel storage and/or disposal charge which does not reflect the fact that some customers will not use interim storage services.

spent fuel

Irradiated nuclear reactor fuel at the end of its useful life.

storage basin

A water-filled, stainless steel-lined pool for the interim storage of spent fuel.

uniform system of accounts

Uniform system of Accounts Prescribed for Public Utilities and Licensees - Title 18 Chapter I of the Code of Federal Regulations-Rules and Regulations of the Federal Energy Regulatory Commission.

use-based fee

Fee for storage and/or disposal based on what services are used. Consistent with dual cost center pricing.

c

<u>variable costs</u>.

Those elements of operating costs which vary directly with the portion of facility capability being utilized. Generally used in contrast to fixed costs which do not vary with the fraction of capability used, but are constant with time.

<u>waste management</u>

The planning, execution & surveillance of essential functions related to the control of radioactive (and nonradioactive) waste, including treatment, solidification, interim or long-term storage, surveillance and disposal.