CHAPTER 6. COST AND SCHEDULE UNCERTAINTIES

This chapter provides information to support assessment of the some of the key uncertainties in the cost and schedule estimates provided in Chapters 4 and 5. Section 6.1 is an introduction to the chapter. Sections 6.2-6.5 detail some of the cost and schedule uncertainties for the various technologies. Section 6.6 provides a quantitative assessment of the sensitivities of the cost estimates to presumed discount rates.

6.1 INTRODUCTION

The uncertainty factors that are cited in this chapter generally map to technical, economic, or schedule issues that are amenable to engineering analysis. It is this set of issues that is addressed in this Report. However, these factors are not necessarily the most important factors that can influence the actual costs and schedules for the alternatives. Some examples of factors which are beyond the scope of this Report but which can nevertheless have significant impacts on schedules (and by extension, cost) include:

International Considerations – The rate of implementation of any alternative will be dependent on negotiations and agreements with the Russian Federation regarding reductions to its stockpiles of surplus weapons-usable plutonium. No such agreements have been negotiated, and considerations of terms and conditions that might be in such agreements would be presumptuous and speculative. In any event, international agreements could result in a regime which drives the plutonium disposition schedule more quickly or more slowly than estimated in Chapter 5.

Assignment of National Priority – The level of resolve in the United States over the next several Congresses and Presidential administrations, as influenced by the timeline of negotiations with Russia, will dictate how rapidly or how slowly plutonium disposition will be completed.

Institutional or Programmatic Issues – All large projects are vulnerable to extensive programmatic delays. As stated in Chapter 5, federal projects can be even more vulnerable to programmatic delays than private sector projects. The causes of programmatic delays can include changes in policy, laws, or regulations, legal challenges, delays in Congressional funding authorization, public opposition and intervention by third parties, as examples

Each of the values assigned to the factors driving the cost and schedule uncertainties are reasonable estimates for planning purposes. The values, however, are not necessarily bounding as less likely scenarios could be postulated that result in outcomes more extreme than those presented here. The values assigned to the factors were estimated in isolation from one another in that each factor was considered to be the only factor involved in assessing a cost or schedule impact. The factors could interact in complex ways; however, insufficient information exists for assessing the impacts of factors operating simultaneously. Therefore, aggregation of uncertainties is not presented.

In the information provided in the following sections, cost impacts are reported in millions of constant 1996 dollars and generally are rounded to the nearest $100 million above the baseline estimates in Chapter 4. The schedule impacts are generally reported in years. The order of the uncertainty factors is arbitrary and does not imply a likelihood or consequence ranking.

6.2 REACTOR ALTERNATIVES

6.2.1 Existing LWRs

In general, LWR MOX fuel technology is well developed and currently operational in Europe. Some technical risks remain for reactor deployment, such as the impact of gallium on fuel fabrication and fuel performance, as outlined in Chapter 3. However, the magnitude of the potential cost and schedule impacts associated with the resolution of the reactor-specific technical issues is small compared to the potential impacts relating to the acquisition of MOX fuel fabrication and irradiation services. One overriding uncertainty that could have significant impact on the use of existing LWRs is the evolving deregulation of the electricity markets. However, impacts related to deregulation have not been assessed.

Table 6-1 identifies some critical factors which could have significant impacts on the cost and schedule estimates in Chapters 4 and 5 for the existing LWR alternative. The bases for the factors are discussed in the accompanying text.

Factor 1:

Utilities will accrue some risk to their investments for transitioning to MOX fuel cycles and likely will require compensation for assuming the risk. In the economic model used in Chapter 4, all of the incremental costs for using MOX fuel rather than uranium fuel are assumed to be paid by the Government and the value of the displaced uranium fuel is credited to the Government. Compensation from the Government to the reactor owners is treated as “irradiation service fees.” This model simplifies the actual business transactions between the reactor owners and the Government for purposes of analysis by separating actual cost incurred from any fees.

The actual business transactions would result from negotiations with selected reactor owners subsequent to a competitive procurement process. In this process, the reactor owners, perhaps in concert with other companies, would propose terms and conditions for providing irradiation services to the Government. The price structures that a reactor owner might use to base its proposal could depend on any number of factors, such as the company’s own financial status, the projected long-term costs for uranium fuels, exposure to financial and technical risks, local electric power market conditions, ability to enhance shareholder value, and assessments of prospective competitors for the disposition mission.

In any event, the net cost to the Government, reflected in this Report as a “fee,” will ultimately be embedded in a framework of an integrated business arrangement yet to be proposed or negotiated.

Estimates for expected LWR irradiation service fees are provided in the Existing LWR Reactor Alternative Summary Report. The estimate in the Reports varies with particulars, but the estimates for the aggregated fee tends to center around $500 million. Note that even if no fee is paid, the reactor owners could receive the benefit of long-term price stability of their fuel supply, which is a tangible economic benefit to the utilities but a cost-free item to the Government.

Table 6-1. ***Approximate Cost and Schedule Impacts for Existing LWRs***

[The order of the factors is arbitrary, and the likelihood of each factor is unknown.]

Factor	*Source of Variation*	*Adjustment or Impact*	*Cost ($M)*	*Schedule (yr)*
1	Fee for irradiation services	Pay utilities a negotiated price for services	up to 500	none
2	Reactor modifications cause dedicated 1 month delay to convert to MOX fuel cycles; incremental replacement power needed	1200 MW of replacement power required for 30 days at each of 5 reactors and at a cost of $29/MWh	+100	+1 month
3	Variation in market price for LEU fuel	Price of LEU fuel rises to $1500 or falls to $1000 per kg heavy metal	-400 to +200	none
4	High level waste repository incurs additional cost for MOX fuel, relative to LEU fuel	The 1 mill per kWh fee is doubled with incremental cost charged to the Government	+200	none
5	Inability to use European fuel fabrication capability	Use a domestic MOX facility exclusively	-100	+4
6	Adverse variation in front end process parameters (including gallium removal) relative to baseline design	Front end operating costs increase by 10% and more extensive use of aqueous processing	+200	0 to +2
7	Modification and construction costs higher than estimated	Cost escalation of front end, MOX fuel fabrication, and reactor plants by 50%	+500	+2

Factor 2:

Although modifications to reactors are expected to be able to be accomplished in a manner that does not impact the implementation of MOX fuel cycles beyond what is already included in the cost estimates, an incremental dedicated one-month shutdown period for each of the five reactors in the existing LWR, existing facilities variant is postulated and characterized here. The Government would be liable for the cost of replacement power during the extended outage.

Factor 3:

The price that an LWR utility pays for its LEU fuel depends on many factors, but the price depends mainly on the cost of uranium ore and enrichment services. The market price for many of the fuels delivered to utilities today varies from about $1000-1500 per kilogram heavy metal (kgHM). The fuel credit in Chapter 4 was calculated using reference market prices for PWR and BWR fuels as $1193 and $1214 per kgHM, respectively. The cost impacts associated with the change in fuel price correspond to the existing LWR, existing facilities variant over the range indicated.

Factor 4:

The fee for disposal of spent LWR fuel is specified in the Nuclear Waste Policy Act as 1 mill per kilowatt-hour. Though not expected, there may be some incremental costs to the repository to enable it to accept the MOX-derived spent fuels that result from plutonium disposition. An additional 1 mill per kilowatt-hour is assigned to cover any incremental repository costs.

Factor 5:

Not using European facilities for initial fuel assemblies results in a 4 year time delay in the existing LWR, existing facilities variant as discussed in Chapter 5. The overall cost for using only American-fabricated fuel is less than the European case since the operating cost for producing fuel domestically in a government-owned, existing facility is less than the cost of buying it at market prices (approximately $800 vs. $1500 per kgHM) as well as minor savings in safeguards and transportation costs. See Table 7.2 in Volume I of the Reactor Alternatives Summary Report for details.

Factor 6:

Material and labor requirements for front end operations may be higher than anticipated. For example, a 10% increase in operating costs would correspond to $100 million. It is assumed that this level of increase in activity could be accommodated without an increase in the schedule. Additionally, if the ARIES process proves to be incapable of generating plutonium powder to meet morphology or gallium concentration criteria, aqueous processing will be required. The cost penalty in converting to aqueous processing will be the sunk cost in ARIES development (assumed to be $50 million) and the cost of establishing an aqueous processing line with the capability to process the entire 50 MT inventory.

This second cost is assumed to be $50 million more than the capital cost of the ARIES process in the baseline design. The operating costs for ARIES and aqueous processing are assumed to be comparable, so that no net increase in operating cost would be realized. Finally, the assumed schedule delay of 2 years stems from the delay in determining the acceptability of ARIES-derived powder for use in reactor fuel.

Factor 7:

Licensing, design, and construction costs may be higher than anticipated. A 50% cost overrun would correspond to $500 million. A 50% variation from the baseline cost would represent the approximate fidelity of the estimate and is a reasonable basis for planning purposes for considering cost overruns. The 50% value also corresponds to the value for cost overruns used with partially complete and evolutionary reactors, as discussed below. A two year schedule delay is also assumed.

6.2.2 CANDU Reactors

Many of the uncertainty factors for existing LWRs also apply to the CANDU alternative, but the impacts would differ. Table 6-2 identifies some critical factors which could have significant impacts on the CANDU reactor cost and schedule estimates. The factors are discussed in the accompanying text.

Factor 1:

See the corresponding discussion under factor 1 in the LWR subsection. Note, though, that the premium associated with fuel price stability for LWR fuel would be less important to the CANDU reactor owner since the CANDU fuel costs are so much lower.

Factor 2:

Although modifications to CANDU reactors are expected to be able to be accomplished in a manner that does not impact the implementation of MOX fuel cycles beyond what is already included in the cost estimates, an additional dedicated one-month shutdown period for each of the four CANDU reactors is characterized here.

Factor 3:

The CANDU MOX fuel fabrication cost estimates are predicated on LWR MOX experience. Owing to their smaller size and other characteristics, CANDU MOX fuel bundle costs may be overestimated by the LWR-derived experience. The values presented in Table 6-1 correspond to different cost estimates prepared by the reactor vendor (AECL) and LANL, respectively. (See Table 2.22 of Volume 2 of the Reactor Alternative Team Summary Report.)

Table 6-2. ***Approximate Cost and Schedule Impacts for CANDU Reactors***

[The order of the factors is arbitrary, and the likelihood of each factor is unknown.]

Factor	*Source of Variation*	*Adjustment or Impact*	*Cost ($M)*	*Schedule (yr)*
1	Fee for irradiation services	Pay utility a negotiated price for services	up to +500	none
2	Reactor modifications cause dedicated 1 month delay to convert to MOX fuel cycles; additional replacement power needed	769 MW of replacement power required for 30 days at each of 4 reactors and at a cost of $29/MWh	+100	+1 month
3	CANDU fuel fabrication costs	Owing to simpler fuel design, CANDU MOX fuel may be less expensive than LEU MOX fuel per kg heavy metal	-700 to -200	none
4	European CANDU MOX fuel fabrication capability	Use European MOX fuel fabrication to facilitate rapid start of CANDU reactors	+200	-2
5	Adverse variation in front end process parameters (including gallium removal) relative to baseline design	Front end operating costs increase by 10% and more extensive use of aqueous processing	+200	0 to +2
6	Modification and construction costs higher than estimated	Cost escalation of front end, MOX, and reactor plants by 50%	+400	+2

Factor 4:

The CANDU cost and schedule data in Chapters 4 and 5 do not assume European fuel fabrication of CANDU MOX fuel. Although the structural designs of CANDU and LWR fuel assemblies are very different, the fabrication of the fuel pellets for the two reactor types, which is the distinguishing feature between uranium and MOX fuel fabrication, is similar. Therefore, it is assumed that half of the LWR four-year schedule compression realized by European LWR MOX fuel fabrication would be realized by European CANDU MOX fuel fabrication. The two year increment implies an approximately $200 million penalty, assuming the CANDU alternative uses 136 MT/yr at a $700 per kgHM premium to purchase the fuel versus producing it (see Table 2-2 and Factor 5 in Section 6.2.1).

Factor 5:

See Factor 6 in Section 6.2.1.

Factor 6:

Licensing, design, and construction costs may be higher than anticipated. A 50% cost overrun would correspond to $400M. A two year schedule delay is also assumed.

6.2.3 Partially Complete and Evolutionary LWRs

The acquisition cost of the partially complete reactors is a major unknown. The actual acquisition price would depend on the business arrangements between the Government and the reactors' owner(s). The terms and conditions in the business arrangements would include factors such as the rights to the power produced, negotiated price of electricity, salvage value of the reactors after the mission is completed, the completion costs for the reactors, and the reactor owners' rights to the equity in their assets. The actual acquisition price would likely be small and perhaps be zero but remains an indeterminate quantity, absent applicable business terms and conditions. Other significant sources of uncertainty for partially complete and evolutionary reactors include the potential for construction cost overruns, the salvage value of the reactors after mission completion, and the market price for electricity. Potential cost and schedule impacts for these factors are shown in Table 6-3 and discussed in the accompanying text.

Factor 1:

The scenario employed here envisions cost overruns for front end, MOX fuel fabrication, and reactor facilities assumed to be as high as 50%. There are historical cases where nuclear facilities have overrun their cost bases by more than 50%. Many of these cases were subject to high cost of capital (not a factor here where costs are reported in constant dollars and costs are paid as accrued) or to institutional issues (beyond the scope of the report). The two year delay was assumed.

Factor 2:

At the end of the plutonium disposition mission, the partially complete and evolutionary reactors will have approximately 25 years remaining on their operating licenses and would be turned over to the private sector. The present value of this operating profit to the private sector, discounted at a private sector real discount rate of 9%, is approximately $2.5 billion when the plutonium disposition mission ends. Taking a 20% discount off its economic value to estimate its market price provides an estimate of $2000 million that DOE could potentially receive in that year from the private sector. The present value of this payment, discounted at the government's discount rate of 5%, is approximately $640 million in 1996.

Table 6-3. ***Approximate Cost and Schedule Impacts for Partially Complete and Evolutionary Reactors***

[The order of the factors is arbitrary, and the likelihood of each factor is unknown.]

Factor	*Source of Variation*	*Adjustment or Impact*	*Cost ($M)*	*Schedule (yr)*
1	Front end and reactor construction costs are higher than estimated	Cost escalation by 50% for partially complete (pc) and evolutionary (ev) reactor alternatives	+1500 pc +3400 ev	+2 +2
2	Salvage value of reactors received at end of Pu disposition mission	Reactors are sold at a projected market prices	-2000	none
3	Market price of electricity varies from baseline forecast	Price of electricity varies from baseline ($29/MWh) to $41/MWh	-3000	none
4	High level waste repository incurs additional cost for MOX fuel, relative to LEU fuel	The 1 mill per kWh fee is doubled	+ 300	none
5	Adverse variation in front end process parameters (including gallium removal) relative to baseline design	Front end operating costs increase by 10% and more extensive use of aqueous processing	+200	none

Factor 3:

The government would receive revenues from the sale of electricity incidental to the plutonium disposition mission. The baseline cost estimates cited in Chapter 4 assume that the electricity can be sold at a prevailing market price of $29/MWh. A recent report on tritium production by Putman, Hayes, and Bartlett cites a high market price of $41/MWh [PHB 1995]. If the high electricity price were realized, the government would receive approximately $3 billion more revenue as shown in Table 6.2.

Factor 4:

See the related discussion in Section 6.2.1.

Factor 5:

See the related discussion in Section 6.2.1. Note that there is no schedule delay, since availability of plutonium powder is not on the critical path for the alternatives in Table 6-3.

6.3 IMMOBILIZATION ALTERNATIVES

An overriding uncertainty for the immobilization variants pertains to the acceptability of the material form of immobilized plutonium to the repository. Until it is licensed, the nature of material forms that will be acceptable to the high level waste repository is an open question. The risk of a final destination also applies to reactor variants but the issue is less important because the repository is being designed to accommodate spent fuels with characteristics similar to MOX-derived spent fuel.

The estimated uncertainties presented in Table 6-4 relate to the can-in-canister variants since these are the best characterized at this time.

<u>Factor 1:</u>

If R&D efforts fail to demonstrate baseline plutonium loadings, lower plutonium loading would be required. Halving the plutonium loading could be due to either a need to reduce the fissile content of the material form for the high level waste repository or due to an inability to demonstrate satisfactory dissolution and immobilization of plutonium in the host matrix during production. Doubling plant capacity would increase capital costs by $40 million (for additional melters) and operating costs by $160 million. Finally, $100 million additional repository costs would be incurred for the additional canisters. The total cost increment is approximately $300 million.

A schedule delay would likely correspond to the cost escalation. However, no estimate is provided due a lack of basis for estimation.

<u>Factor 2:</u>

If immobilized waste form qualification issues arise, the program might experience additional research, development, and licensing expenses as well as delays in implementation. It is assumed that additional research, development, and licensing expenditures of $100 million would be experienced. The corrective actions would be on the critical path so that a schedule delay of 2 years is assumed. Note that this corresponds to approximately doubling the current baseline waste form qualification cost estimate of $115million.

<u>Factor 3:</u>

Factor 3 refers to a postulated 3 year delay in DWPF operations that prevents placement of cans in canisters and filling them with high level waste. The plutonium-loaded cans would be produced on schedule and stored. Additional storage costs would be approximately $20 million.

Table 6-4. ***Approximate Cost and Schedule Impacts for Immobilization***

[The order of the factors is arbitrary, and the likelihood of each factor is unknown.]

Factor	*Source of Variation*	*Adjustment or Impact*	*Cost ($M)*	*Schedule (yr)*
1	Plutonium loading is too high; plutonium concentration drops in half	Double plant capacity to accommodate additional throughput, more logs to repository	+300	not estimated
2	Additional analyses and experiments required for form qualification	Additional costs and schedule delay	+100	+2
3	DWPF operations delay causes delay in plutonium disposition mission	Requires storage of Pu-loaded cans for 3 years	+20	+3
4	Plutonium disposition mission causes unanticipated impacts on DWPF operations	Additional facilities, hardware, and procedures must be applied to other DWPF operations	+30	none
5	Adverse variation in front end process parameters relative to baseline design	Front end operating costs increase by 10%	+100	none
6	Reduction in glass or ceramic formation times	50% reduction in cycle time, reduced melter or sintering furnace capacity and operating costs	-100	none
7	Modification and construction costs higher than estimated	Cost escalation of front end and immobilization plants by 50%	+300	+2
8	Assigned unit cost for canister disposal too low	The estimated unit cost for canister disposal is doubled	+100	none
9	Baseline can-in-canister design found unacceptable from nonproliferation perspective	Redesign can-in-canister to address nonproliferation concerns	+10	none

Factor 4:

The baseline design assumes that the plutonium disposition mission will have some impacts on DWPF operations. The cost of these impacts is included in the cost estimates in Chapters 4 and 5. For example, the baseline design includes security upgrades and facilities such as vaults, a local PIDAS fence, DWPF upgrades, and storage building upgrades. In addition, the design includes the addition of 25 full time operators at DWPF and 55 full time security personnel. A 50% contingency on these costs corresponds to approximately $30 million.

Factor 5:

As indicated in the discussion of the reactor alternatives, variation in front end process parameters may lead to a 10% increase in operating costs, or $100 million. Note that the reactor-specific morphology and gallium contamination impacts do not apply to the immobilization alternatives.

Factor 6:

Recent experimental results indicate that melting or sintering cycle times could be 1/2 of those assumed in the baseline designs. Capital and operating costs would be reduced by $25 million and $75 million, respectively.

Factor 7:

As indicated in the reactor discussion, a 50% cost overrun relative to estimates based upon preconceptual designs is considered.

Factor 8:

The cost estimated in the baseline cost estimate for canister disposal corresponds to the assigned cost for disposal of the existing DWPF canisters. The actual cost for DWPF canisters is indeterminate at present and it is not clear that plutonium-loaded canisters will be charged at the same rate. A factor of two increase in the cost for waste disposal is judged to envelop a wide range of possible outcomes in the actual costs for canisters.

Factor 9:

The current can-in-canister design may be deemed unacceptable from a safeguards and security perspective by the U. S. Government, the Russian Federation, or the international safeguards community. However, a recent report on the proliferation vulnerability of the plutonium disposition alternatives supports the position that can-in-canister system design modifications can likely mitigate proliferation vulnerabilities[1]. For example, different can materials may be needed to prevent separation of the plutonium-loaded cans from the surrounding glass matrix or smaller cans may have to be used to more closely approximate a homogeneous mixture of plutonium and other radioactive material. It is unlikely that mechanical or materials redesign costs would exceed $10 million. No schedule impact is anticipated.

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[1] Proliferation Vulnerability Red Team Report, SAND97-8203-UC-700, October 1996.

6.4 BOREHOLE ALTERNATIVES

In general, licensing and siting are key uncertainties for the borehole alternatives. These uncertainties are judged to override all of the technical uncertainties associated with the borehole alternatives. Whereas some aspects associated with licensing and siting are factors that can be analyzed by engineering methods, the most important ones are not amenable to engineering analysis. Thus, assignment of risk to explicit uncertainty factors has not been attempted.

6.5 HYBRID ALTERNATIVES

A reactor/immobilization hybrid approach offers some significant possibilities for mitigating the impacts of the cost and schedule uncertainties cited in previous subsections, as well as the opportunity to adjust to major post-ROD policy changes that might preclude the deployment of one of the two technologies in the hybrid. As an example, if irradiation fees required by utilities were determined to be excessively large, the reactor technology could be dropped at that time and all the material directed to scaled-up immobilization facilities. Conversely, if the immobilization research and development does not progress as expected, the immobilization technology could be dropped and all the material then directed to the scaled-up MOX fuel fabrication and reactor facilities. Thus, the hybrid alternatives provide additional flexibilityat the expense of a relatively small increment in investment costs.

Table 6-5. ***Approximate Cost and Schedule Impacts for Reactor/Immobilization Hybrids***

[The order of the factors is arbitrary, and the likelihood of each factor is unknown.]

Factor	*Source of Variation*	*Adjustment or Impact*	*Cost ($M)*	*Schedule (yr)*
1	Unacceptable costs or technical difficulties with reactor or immobilization technologies	Implement only one of the two technologies in the hybrid	-100	not estimated
2	Fee for irradiation services	Pay utilities a negotiated price for services	up to +300	none
3	Plutonium loading is too high; plutonium concentration drops in half	Increase vitrification plant capacity and/or operate plant longer	+100	none

Factor 1:

If unacceptable cost or technical issues for MOX fuel are encountered[2] prior to construction, the immobilization facilities can be scaled-up to process 50 MT of plutonium, rather

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[2] This assumes the LWR hybrid; the CANDU hybrid would be similar.

than the 17 MT feed stream assumed in the baseline hybrid example. Two types of costs would be incurred: the reactor alternative licensing and R&D costs and the costs of immobilization facilities to accommodate all 50 MT of plutonium. The first cost is approximately $250 million and the second cost is $1830 million. Hence, the total cost is $2080, which is $100 million less than the cost of the LWR/immobilization hybrid. Note that this cost reduction is realized rather than the large cost overruns that would be experienced if the 50 MT reactor alternative had been selected rather than the hybrid alternative.

Similarly, if unacceptable cost or technical issues for can-in-canister immobilization are encountered prior to construction, the MOX fuel fabrication and reactor facilities can be scaled-up to process 50 MT of plutonium, rather than the 33 MT feed stream assumed in the baseline hybrid example. The can-in-canister immobilization alternative licensing and R&D costs are approximately $120 million and the 50 MT MOX fuel fabrication and reactor facilities costs are $1920 million. Hence, the total cost is $2040, which is $140 million less than the cost of the LWR/immobilization hybrid.

Note that, coincidentally, the net savings in either event is about $100 million. These savings could be partially or wholly offset by the other uncertainties identified in Tables 6-1, 6-2, and 6-4, which would still apply as appropriate.

Factors 2-3:

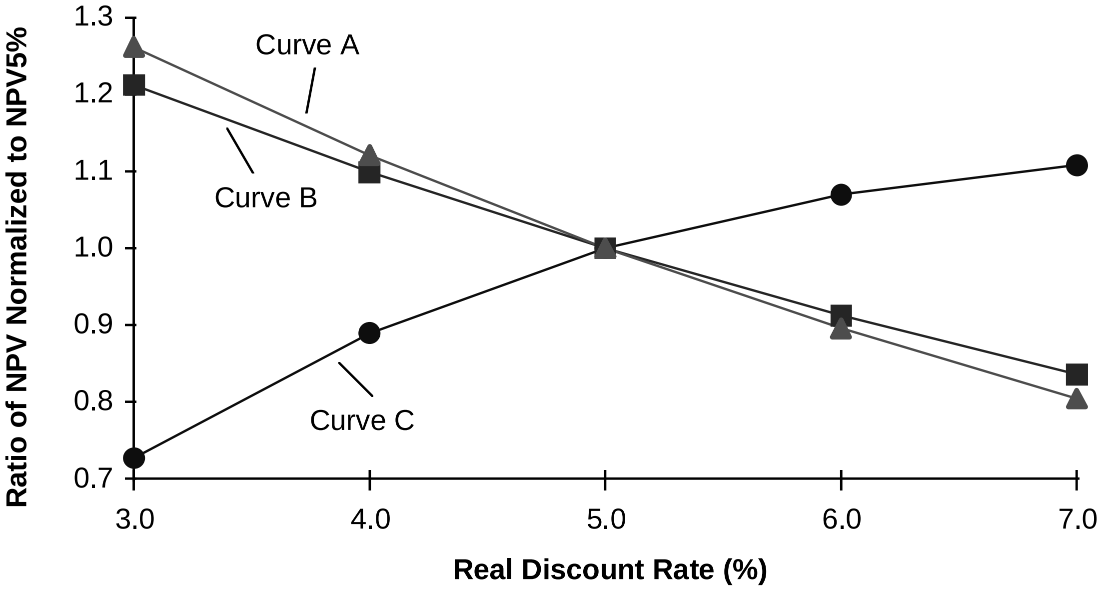
The last factors shown in Table 6-5 are representative of many other factors from Tables 6-1, 6-2, and 6-4 and demonstrate that individual cost and schedule impacts are less for most uncertainty factors in a hybrid approach. Because each of the two technologies of the hybrid would process a lower amount of material than its stand-alone counterpart, the magnitude of the impacts tend to be proportionally reduced.

6.6 SENSITIVITY TO DISCOUNT RATES

Discounted cost analyses are necessary to properly reflect the cost of capital over time which is generally assessed by applying an appropriate discount rate to determine the present value of future costs and benefits. However, since the cost of capital can never be determined *a priori*, it is important to understand how sensitive the cost estimates are to variations in the discount rate. Figure 6-1 depicts the sensitivity of the discounted cost as the discount rate varies from 3 to 7 % per year. The data are reported as the ratio of the net present value at a given discount rate to the discount rate base case of 5 % for the particular variant to normalize data to the base case analyses. The three variants selected have been chosen to represent the three type of cash flow profiles for the suite of alternatives:

Curve	*Variant*	*Cash Flow Profile*
A	Can-in-canister	All costs; no electric power revenues; no uranium fuel displacement credits
B	Existing LWRs, existing facilities	Credits but no revenues
C	Partially complete reactors	Revenues but no credits

Figure 6-1. *Discount Rate Sensitivity*



From Figure 6-1, the following observations are offered:

1. The behavior of Curve A closely mirrors that of Curve B. This could be expected as the net cash flow profiles for the underlying variants are very similar. Importantly, the sensitivity to a 1% change in the discount rate is only 10% to 15% from the base case, which is small compared to the uncertainties in the cost estimates.

2. Curve B is slightly less sensitive than Curve A to the discount rate variations due to the small effect of the fuel credits, which tend to make cash flows in out-years nearer to zero than they would otherwise be. (Zero net cash flow in any year is unaffected by discount rate fluctuations.)
3. The trend for Curves A and B is that the normalized discounted cost increases with decreasing discount rate, as would be expected.
4. The behavior of Curve C is unlike that for Curves A and B. Note that the net present cost increases with increasing discount rate. This is readily explained by recognizing that the revenues for the alternative tend to accrue later in time than costs, thus making the present value of out-year revenues smaller as the discount rate increases.

The following illustrates the use of these sensitivity curves:

Assume an alternative without any revenues and a base case life cycle cost of $2000 million. If one wanted to know what the approximate life cycle cost would be at a 4% discount rate, the ratio of about 1.1 would be selected from Figure 6-1. Multiplying 1.1 times the base discounted life cycle cost yields a life cycle cost discounted at 4% of approximately $2200 million.

Discounted cost analyses can be misinterpreted to imply that the mission ought to be deferred in order to lower present value cost to the Government. Deferral of costs does, of course, reduce the net present cost to the Government. However, deferral of the plutonium disposition mission is also realized, a deferral which might pose an immeasurable threat/cost to US and international security. Conceptually, one must consider a trade off between the benefits of completing the mission earlier verses the additional costs incurred in doing so.

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