CHAPTER 4. COST SUMMARIES

Cost estimation methodology is described in Section 4.1. Costs for the reactor, immobilization, deep borehole, and hybrid alternatives are presented in Sections 4.2 through 4.5, respectively. Section 4.6 provides a summary and comparison of all alternative costs. Discussion of cost-related uncertainties is deferred to Chapter 6.

4.1 COST ESTIMATION METHODOLOGY

Cost estimates for each major facility in each alternative were generated using the 24 cost categories described in Appendix C. These 24 categories are aggregated into three higher-level cost categories: pre-operational, capital, and operating. Pre-operational costs include research and development, licensing, conceptual design, and startup costs. Capital costs include engineering, capital equipment, and construction costs. The capital cost represents the "line item" Congressional appropriation that would be required to fund the project. Pre-operational and capital costs would generally be incurred within the first ten years of the project and would require near-term Congressional funding. This near-term government funding requirement will be referred to as the *investment cost*[1]. Other life cycle costs, which will be referred to as *operating cost*, include staffing, maintenance, consumables, waste management, decontamination and decommissioning costs for performing the plutonium disposition mission. Operating costs that would be incurred independent of plutonium disposition activities, such as operation of the Defense Waste Processing Facility (DWPF) for the high-level waste mission or operation of existing reactors for power production, are not included.

Fuel displacement credits, which reflect the cost recovery that would be realized by displacement of uranium fuel by MOX fuel, are included in the estimates for existing reactors alternatives. Potential r*evenues* that might be realized by the partially complete and evolutionary reactors are estimated. Investment cost, operating cost, fuel displacement credits, and revenues are combined to yield a net *life cycle cost* for the alternative.

Life cycle costs are reported in terms of undiscounted constant dollars (1996$)[2] and discounted net present value. For discounted cost calculations, constant dollar cash flow streams are distributed over time, according to the schedules reported in Chapter 5, and discounted on an annual basis. Office of Management and Budget (OMB) Circular No. A-94 recommends using a real discount rate that has been adjusted to eliminate the effect of

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[1] In government accounting parlance, pre-operational cost is referred to as "operating-funded costs" or OPC, capital cost is referred to as "total estimated cost" or TEC, and investment cost is referred to as "total project cost" (TPC). Note that the relationship OPC + TEC = TPC holds.

[2] Actual cash flows associated with future expenditures are reduced to account for inflation effects to yield equivalent expenditures in terms of 1996 dollars (1996$). For example, if inflation is 3% per year, an expenditure of $1.03 in 1997 would be equivalent to $1.00 measured in 1996$. Use of constant dollars simplifies cost estimation and accounting.

expected inflation to discount constant-dollar costs and benefits (including revenues). OMB issues annual revisions to the recommended rates for use during that year. In January 1995, OMB recommended a real discount rate (for 30 years) of 4.9%, but in January 1996 recommended a real discount rate (for 30 years) of 3.0%. The real discount rate can be approximated by subtracting expected inflation from the nominal interest rate. The published yields for long term treasury securities (maturing in the 2010 to 2020 timeframe) average greater than 7%. Subtracting OMB's forecast of expected inflation rate of about 2.7% results in real discount rates of approximately 4.5%. The Department, in its Technical Reference Report for Tritium Supply and Recycle, October 1995, used a real discount rate of 4.9%. Therefore, for this report in which the estimates have less precision, the discount rate represents a midpoint in the range of discount rates between 3 and 7 percent which have been utilized over recent years. The sensitivity of the results to the discount rate is discussed in Section 6.6.

Depending upon the alternative, costs were estimated for new facilities at DOE sites with no plutonium infrastructure (denoted as "greenfield" in this report), new facilities at DOE sites with plutonium-handling infrastructure or unused areas in existing buildings on such DOE sites (denoted as "existing facilities" in this report). Construction of facilities at greenfield sites would require development of site infrastructure such as health physics, analytical laboratories and waste handling. New facilities located at DOE sites with plutonium handling infrastructure would realize substantial cost savings associated with shared usage of such site infrastructure. Finally, maximum cost savings and schedule compression could be realized by modifying and using facilities, including buildings, at DOE sites with appropriate infrastructure. Use of modified facilities would reduce the costs of structures as well as heating, ventilation, and air conditioning, electrical, water, and other support systems. Cost estimates for usage of Building 221F and other facilities at Savannah River were developed in order to illustrate the level of savings that could be realized, but other DOE sites might be utilized. No recommendation regarding siting of facilities at Savannah River is implied by this example. A substantial portion of these savings could be realized by using the existing site infrastructure even if a new building is erected. MOX fuel fabrication costs were also calculated under private and government ownership arrangements. Finally, cost estimates for front-end facilities presume collocation of ARIES and non-pit processing equipment. If ARIES and non-pit processing equipment were not collocated, costs would be higher due to the duplication of some support infrastructure.

These preliminary cost estimates were generated based on pre-conceptual designs using various assumptions and approximations related to outcomes of research and development programs, licensing efforts, and negotiations with suppliers. Because designs are at the pre-conceptual level of definition, the estimates are subject to substantial uncertainty. Several of the more important sources of uncertainty have been identified in this chapter. Quantification of some of the key cost uncertainties is provided in Chapter 6.

4.2 REACTOR ALTERNATIVES COSTS

4.2.1 Assumptions

The financial structure of the reactor alternatives described in Chapter 2 tends to be more complex than the others. Key assumptions that are incorporated in their analysis are as follows:

1) Estimates of incentive fees, if any, that might be paid to utilities for MOX fuel irradiation services have not been included in reactor alternatives costs. Such fees are a part of business arrangements yet to be proposed and negotiated and may be in addition to the expected reimbursable costs that would be incurred by the utilities for MOX irradiation services. The magnitude of the fees, if any, represents a significant cost uncertainty which is discussed in Chapter 6.

2) Operating costs shown for all existing reactors are only the net additional costs for MOX fuel operations compared to operations with LEU or natural uranium fuel. For the partially complete and evolutionary reactors, operating costs incurred during uranium fuel operations are not included in the data reported here. The operating costs for the reactor alternatives include the operational costs for the front-end facility and the MOX fuel facility as well as any additional costs at the reactor site unique to plutonium disposition.

3) For the existing LWR and CANDU reactor alternatives, a credit is taken for the cost of the private utility’s uranium fuel that the government-produced MOX fuel displaces.

4) Unless otherwise noted, government ownership of plutonium processing and MOX fuel fabrication facilities is assumed.

5) For all of the reactor variants analyzed in this Report, plutonium processing and MOX fuel fabrication equipment is placed in existing buildings at DOE sites with existing plutonium handling infrastructure, except for the existing reactor, Greenfield variant. The private MOX fuel facility approach, which is discussed in this Report, uses a new building on an existing DOE site with plutonium handling infrastructure.

6) Existing LWR and CANDU reactors are privately owned and operated, with revenues from electricity sales accruing to the utilities.

7) The cost for thermally processing plutonium from pits to remove gallium is included in the estimates for conservatism, even though the gallium removal operations are believed to be unnecessary.

8) High-level waste repository costs are included as part of the operating costs of the partially complete and evolutionary reactors ($0.001/kWh).

9) For the partially complete and evolutionary reactor alternatives, there are special financial assumptions which apply:

   - The revenue streams for these alternatives are priced at $ 0.029/kWh, a typical but conservative value for inflation-adjusted long-term electricity market price. (See Chapter 6 for alternative assumptions.)
   - No attempt to partition the revenue stream between the Government and private sector entities has been attempted since the split, if any, is subject to business arrangements yet to be proposed and negotiated (for partially complete reactor alternative only).
   - No salvage value is assigned to the reactors after they complete the plutonium disposition mission. The actual salvage value to be realized depends on a variety of unknown factors, especially the business arrangements yet to be proposed and negotiated. (See Chapter 6 for alternative assumptions.)
   - Only the costs and revenues for the reactors which relate to using MOX fuel are considered.

10) The cost for European fuel fabrication of LUAs and initial core loads for existing LWRs and CANDU reactors is $1500 per kilogram heavy metal. Use of European MOX fuel capacity is not included in the baseline cost estimate for CANDU reactors. The sensitivity to the European MOX fuel cost is explored in Section 6.2 for both LWRs and CANDU reactors.

4.2.2 Cost Analysis

Investment costs, undiscounted life cycle costs, and discounted life cycle costs of existing reactor alternatives are summarized in Figure 4-1, with supporting detail of costs by facility shown in Table 4-1.[3]

As indicated by the data, the existing LWR, existing facilities variant requires approximately $1 billion[4] in investment cost to design, license, and construct/modify plutonium processing (front-end) and MOX fuel fabrication facilities and to pay for modifications, licensing, and fuel test and qualifications for the privately-owned reactors. Of this investment cost $750 million is required for the plutonium processing and MOX fuel fabrication facilities at an existing site with existing plutonium handling infrastructure. Similar co-functional and co-

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[3] The information derives from the Reactor Alternative Summary Reports. Differences between costs here and the Reactor Alternative Summery Reports, generally less that 2%, derive from a series of rounding errors and small differences in schedules (a few weeks over several years). These differences are not material to this Report. The Reactor Alternative Summery Reports cost basis also includes business-related cost items that are not included in the cost basis in this Report. These business-related costs are discussed in Chapter 6.

[4] All costs are undiscounted costs unless indicated otherwise.

located facilities at a greenfield site would cost $1050 million, or $300 million more. The CANDU MOX fuel fabrication facility investment cost is $40 million higher than that for the LWR MOX fuel facilities. This is due to the larger plant capacity needed to support higher heavy metal throughput for fabrication of the lower-enrichment CANDU fuel. However, the higher investment cost for the MOX fuel plant for the CANDU alternative relative to the existing LWR, existing facilities variant is more than offset by the lower investment costs required to convert CANDU reactors to MOX fuel cycles compared to the LWR transition. In general, the front-end plutonium processing facilities account for about one third of the investment cost in the existing LWR and CANDU variants. Relative to operating costs, the CANDU MOX fuel fabrication operating costs are higher than the costs of fabricating LWR MOX fuel, which can also be attributed to the greater heavy metal throughput associated with CANDU fuel.

Figure 4-1. ***Existing Reactor Alternatives Costs***

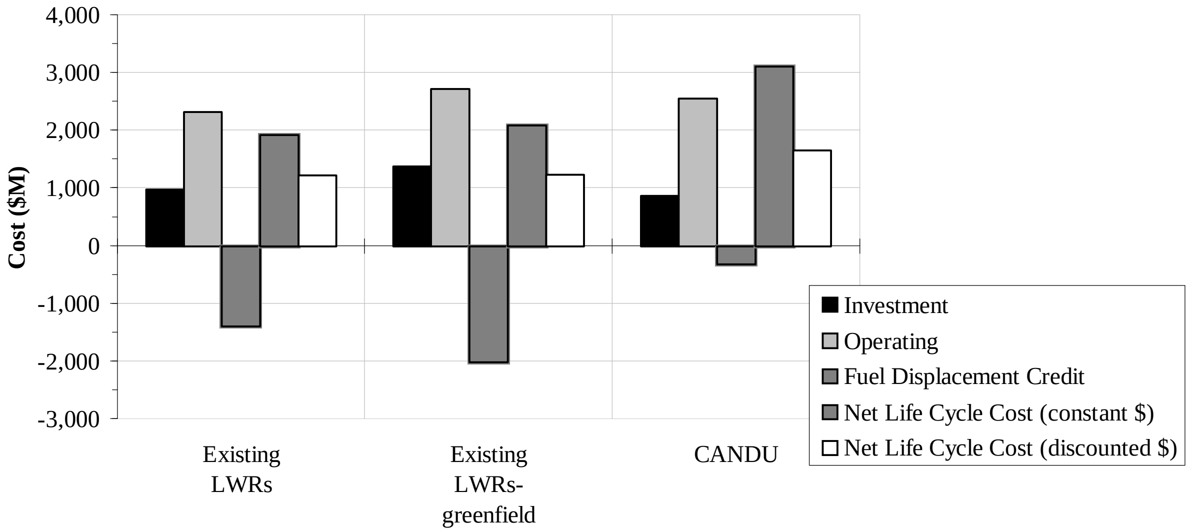


Table 4-1. ***Existing Reactor Alternatives Costs***

		Constant $ (millions)				*Discounted $ (millions)*			
Reactor Alternative	*Facility*	*Investment*	*Operating*	*Fuel Displacement Credit*	*Net Life Cycle Cost*	*Investment*	*Operating*	*Fuel Displacement Credit*	*Net Life Cycle Cost*
Existing LWRs, Existing Facilities	Front-end	340	1050	0	1390				
	MOX Fab	410	1130 [2]	-1390	150				
	Reactor	230	150	0	380				
	Total	**980**	**2330**	**-1390**	**1920**	**710**	**1230**	**-720**	**1220**
Existing LWRs, Greenfield Facilities[1]	Front-end	1050	2590	-2010	1630				
	Reactor	330	130	0	460				
	Total	**1380**	**2720**	**-2010**	**2090**	**950**	**1110**	**-820**	**1240**
CANDU	Front-end	320	1090	0	1410				
	MOX Fab	450	1430	-320	1560				
	Reactor	100	40	0	140				
	Total	**870**	**2560**	**-320**	**3110**	**630**	**1180**	**-150**	**1660**

[1] Because the greenfield front-end and MOX fuel fabrication facilities are collocated in the Existing Reactor, Greenfield variant, their costs are combined in the table.

[2] $240 M of this cost is for the fuel fabricated in Europe.

The uranium fuel displacement credit for the existing LWR, existing facilities variant (a five PWR case) is $1.4 billion, which is equivalent to the cost of LEU that is displaced by MOX fuel. The credits are $2 billion for the LWR, Greenfield facilities variant (a four BWR case), and $0.3 billion for the CANDU reactors. The credit is higher for the BWR case because these reactors use fuel with lower plutonium loading; hence, more uranium fuel assemblies are displaced by MOX fuel assemblies using the 50 MT of surplus plutonium. The lower CANDU MOX fuel credits reflect the lower cost of the natural uranium fuel used by the CANDU reactors. (The cost of natural uranium CANDU fuel is only $100 per kilogram of uranium, compared to approximately $1200 per kilogram of uranium for the low-enriched fuel used in LWRs. The cost figures in Table 4-1 reflect that the CANDU MOX fuel bundles replace natural uranium fuel bundles on an equivalent energy extraction basis, not on kilogram of heavy metal basis.) Note that the comparison of costs is the government's production cost of MOX fuel against the market price for LEU or natural uranium fuel; the latter cost includes capital cost recovery and return to the investors whereas the former does not include these costs.

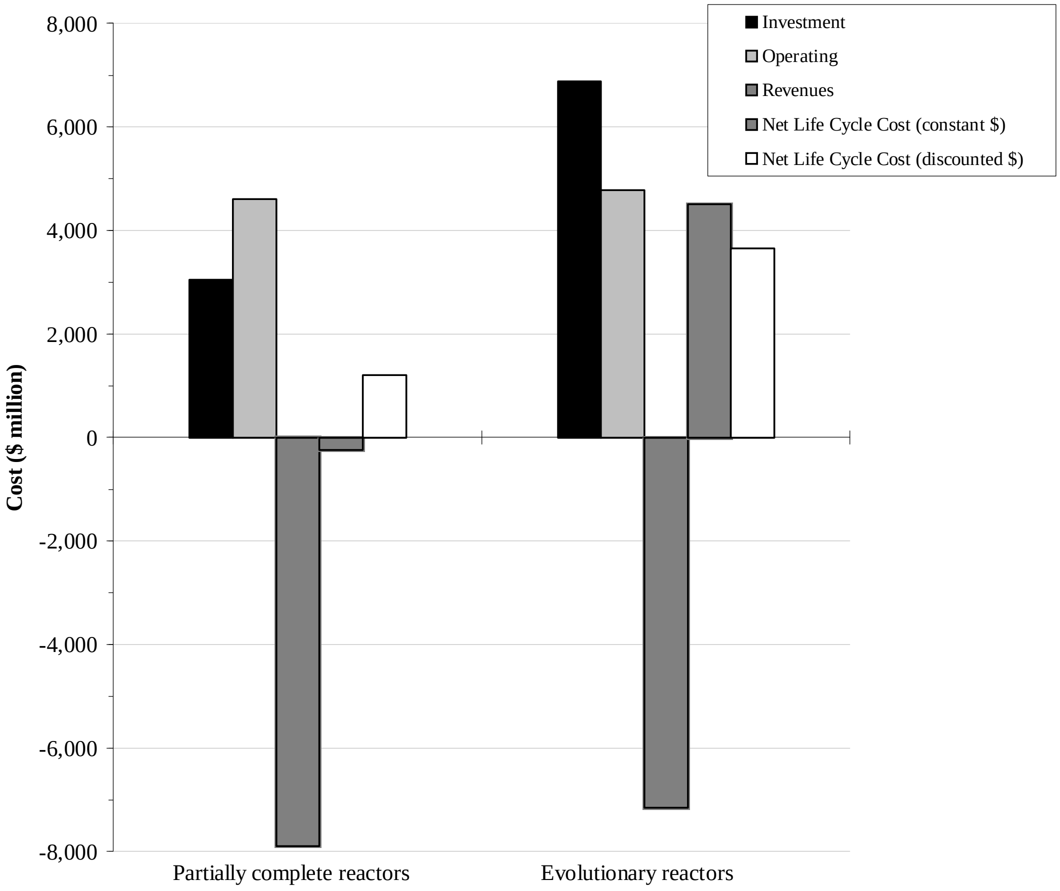
Government ownership of the MOX fuel fabrication facility saves the government approximately $600 million. This is due to the government's lower cost of capital relative to private financing, no interest during construction, and no need for a rate of return for private companies. Privately-financed facilities would have to recover the higher capital costs through higher MOX fuel charges to the utilities that use the fuel and, ultimately, to the government. In no case can MOX fuel complete economically with uranium fuel.

The partially complete and new evolutionary reactors require substantially greater investment and operating expenditures relative to the other reactor alternatives. Comparing Figure 4-1 and Figure 4-2, investment costs are $2 billion to almost $6 billion more than that for the existing reactors to cover the costs for completing or building the reactors. Operating costs, including the cost of operating the front-end facility, the MOX fuel fabrication facility, and the reactors, are approximately $3 billion more than existing reactor costs. Most of the difference derives from the reactor operational costs. For existing reactors, only the incremental costs associated with MOX fuel deployment above uranium fuel utilization accrue to the plutonium disposition mission. By contrast, the entire operating costs for the partially complete and evolutionary reactors accrue to the plutonium disposition mission since these reactors would not have operated had not the plutonium disposition mission required their use. Furthermore, no credit can be taken for uranium fuel displacement.

Table 4-2. *Costs of Partially Complete and Evolutionary Reactors*

		Constant $ (millions)				*Discounted $ (millions)*			
Reactor Alternative	***Facility***	***Investment***	***Operating***	***Revenues***	***Net Life Cycle Cost***	***Investment***	***Operating***	***Revenues***	***Net Life Cycle Cost***
Partially Complete LWRs	Front-end	320	1090	0	1410				
	MOX Fab	350	1120	0	1470				
	Reactor	2380	2400	-7890	-3110				
	Total	**3050**	**4610**	**-7890**	**-230**	**2190**	**1860**	**-2830**	**1210**
Evolutionary LWRs	Front-end	320	1090	0	1410				
	MOX Fab	350	710	0	1060				
	Reactor	6210	2980	-7150	2040				
	Total	**6880**	**4780**	**-7150**	**4510**	**4190**	**1780**	**-2310**	**3660**

Figure 4-2. ***Costs of Partially Complete and Evolutionary Reactors***



4.2.3 Potential Revenues

For the partially complete and evolutionary reactor alternatives, revenues will accrue to the owners. The gross amount of revenues from the reactors are shown Table 4-2, as if they accrue to the government. However, the extent to which the revenues might impact net plutonium disposition mission costs to the government are not known since ultimately the share of the revenues due to the government for the partially complete alternative, if any, is not known.

Regarding evolutionary reactors, the Department in its Record of Decision on Tritium Production did not choose to construct new reactor(s) for tritium supply. Rather the Department chose to pursue a strategy of evaluating (1) using existing commercial light water reactors and (2) construction of a linear accelerator.[5] Subsequently, the Department

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[5] DOE News Release, October 10, 1995.

issued a request for expressions of interest for tritium production that also solicited interest regarding the future potential use of mixed oxide fuel from surplus weapons plutonium either coincident with or separate from tritium production.

Through the initial responses to the request for expressions of interest, the Department was able to confirm that there appears to be sufficient commercial interest in use of existing or partially complete light water reactors for plutonium disposition mission alone and/or in a joint mission of tritium production and plutonium disposition. The use of existing reactors or partially complete would be subject to formal procurement procedures and business negotiations as well as resolution of licensing and other technical and policy issues.

In a Putnam, Hayes and Barlett final cost report on costs of tritium production, the authors used a range of revenues based upon a spectrum of assumptions concerning the unit sales price for electricity.[6] Using the data provided for the lowest case of forcasted revenues for the period of 2010 through 2020 in the southeast, electric sales price projections based upon $0.029/kWh were used to estimate revenues and are included in computing net life cycle costs shown in Figure 4-2.

If commercial interests should choose to complete partially complete reactors or build new reactors for commercial power generation and/or Government programs, such as the potential missions of tritium production and plutonium disposition, these reactors would, of course, be essentially the same as the larger pool of already licensed and operating commercial nuclear plants.

(Information previously here was moved to Chapter 6.)

4.3 IMMOBILIZATION ALTERNATIVES COSTS

4.3.1 Assumptions

Immobilization variants, described in detail in Chapter 2, incorporate the following economic assumptions:

1. The government owns all facilities.
2. Except where noted for greenfield alternatives, plutonium processing and immobilization equipment are in existing buildings at DOE sites with existing plutonium handing infrastructure. For the electrometallurgical treatment alternative, costs were based on co-located front-end processing at ANL-W, where some additional capacity would be required.

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[6] Putnam, Hayes, and Bartlett, Inc., *DOE Tritium Production Options: PHB Final Report on Cost Analysis* (1 September 1995, text revisions 15 October 1995).

3. Immobilized material would be stored until it could be transferred to the federal high-level waste management system.
4. The fee for disposal of additional canisters resulting from plutonium disposition mission at a high-level waste repository is $500,000 per canister, consistent with expected cost for high-level waste canisters associated with the current DWPF program.

4.3.2 Cost Analysis

Investment, operating, undiscounted life cycle, and discounted life cycle costs of immobilization variants are summarized in Figure 4-3, with supporting detail of costs by facility shown in Table 4-3.

Figure 4-3. ***Immobilization Investment and Life Cycle Costs***

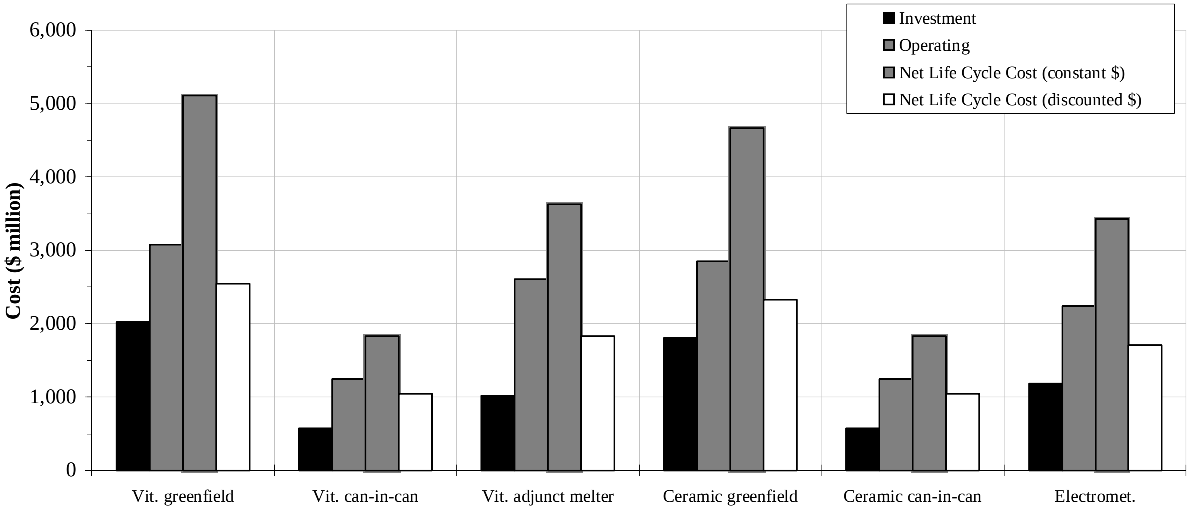


Table 4-3. *Immobilization Alternatives Costs*

		Constant $ (millions)			*Discounted $ (millions)*		
Immobilization Alternative	***Facility***	***Investment***	***Operating***	***Net Life Cycle Cost***	***Investment***	***Operating***	***Net Life Cycle Cost***
Vitrification Greenfield	Front-end	1000	980	1980			
	Immobilization	1030	1800	2830			
	Repository	0	300	300			
	Total	**2030**	**3080**	**5110**	**1250**	**1300**	**2550**
Vitrification Can-in-Canister	Front-end	360	980	1340			
	Immobilization	220	170	390			
	Repository	0	100	100			
	Total	**580**	**1250**	**1830**	**410**	**640**	**1050**
Vitrification Adjunct Melter	Front-end	340	980	1320			
	Immobilization	680	1330	2010			
	Repository	0	300	300			
	Total	**1020**	**2610**	**3630**	**680**	**1150**	**1830**
Ceramic Greenfield	Front-end	860	820	1680			
	Immobilization	950	1720	2670			
	Repository	0	320	320			
	Total	**1810**	**2860**	**4670**	**1120**	**1200**	**2330**
Ceramic Can-in-Canister	Front-end	360	980	1340			
	Immobilization	220	170	390			
	Repository	0	100	100			
	Total	**580**	**1250**	**1830**	**410**	**640**	**1050**
Electrometallurgical Treatment[1]	Front-end	730	890	1620			
	Immobilization	460	870	1330			
	Repository	0	480	480			
	Total	**1190**	**2240**	**3430**	**770**	**940**	**1710**

[1] Costs are based upon a stand-alone plutonium disposition mission. Cost sharing with DOE programs for the treatment of spent fuel has the potential to reduced costs by approximately $600 million.

Existing facilities and waste disposal operations provide the opportunity for significant cost savings for the plutonium disposition mission. As indicated by the data, the investment cost of the vitrification can-in-canister variant is approximately one fourth the greenfield vitrification variant investment cost. The cost ratio is about a factor of three for the ceramic greenfield versus the ceramic can-in-canister variant. Less dramatic investment savings can be realized using an adjunct melter strategy for vitrification, where costs are one half of the greenfield vitrification investment costs. Note that the front-end costs account for half of the investment costs for the two greenfield variants and well over half of the can-in-canister variants. The costs for the can-in-canister variants appear identical in the table; however, the variants were costed separately on their own bases.

The investment costs for the vitrification greenfield front-end facilities are approximately $150 million more than the ceramic greenfield front-end due to the inclusion of a first stage melter in the vitrification front-end facility. The investment cost of the electrometallurgical treatment variant is less than the cost of greenfield variants, but more than the cost of can-in-canister variants. The front-end facility for electrometallurgical treatment accounts for approximately two thirds of the investment costs. However, those costs could be reduced by performing some of the front-end process steps at other locations, thereby avoiding the need to add additional facility space necessary to co-locate all operations at ANL-W.

Operating costs range from \$1.2 billion for the can-in-canister variants to over \$3 billion for the vitrification greenfield variant. Use of DWPF reduces immobilization facility operating costs by a factor of ten relative to greenfield immobilization facilities for the vitrification and ceramic immobilization approaches. Use of DWPF facilities for the can-in-canister variants relative to the greenfield variants reduces overall operating costs by a factor of two. Repository costs refer to the canisters resulting from disposition operations. The electrometallurgical treatment alternative is assumed to process plutonium independent of a mission to treat spent nuclear fuel. If the plutonium disposition mission is conducted simultaneously with the operations to treat spent nuclear fuel, then approximately \$600 million could be saved through the sharing of concurrent operating, storage, and waste disposal costs.

Life cycle costs of can-in-canister concepts are also significantly lower than for other immobilization variants. Discounted life cycle costs range from \$1.0 billion for the can-in-canister variants to \$2.6 billion for the vitrification greenfield variant.

(Information previously here was moved to Chapter 6.)

4.4 DEEP BOREHOLE ALTERNATIVES COSTS

4.4.1 Assumptions

Deep borehole alternatives, described in detail in Chapter 2, incorporate the following economic assumptions:

1) Government ownership of plutonium processing and borehole facilities is assumed.
2) Front-end and immobilization facilities are collocated at a government-owned site with plutonium processing infrastructure. Front-end processes are located in existing buildings where possible.
3) Borehole facilities are sited at a generic, non-DOE site.

4.4.2 Cost Analysis

Investment costs, operating costs, undiscounted life cycle costs, and discounted life cycle costs of borehole alternatives are summarized in Figure 4-4, with supporting detail of costs by facility shown in Table 4-4.

Figure 4-4. ***Borehole Investment and Life Cycle Costs***

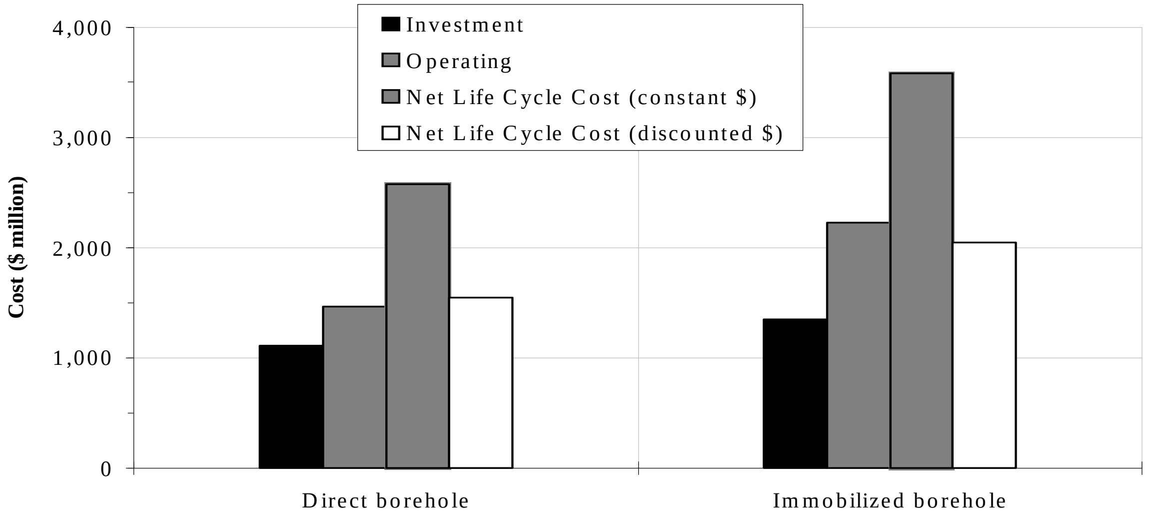


Table 4-4. ***Deep Borehole Alternatives Costs***

		Constant $ (millions)			*Discounted $ (millions)*		
Deep Borehole Alternative	***Facility***	***Investment***	***Operating***	***Net Life Cycle Cost***	***Investment***	***Operating***	***Net Life Cycle Cost***
Direct Emplacement	Front-end	240	800	1040			
	Borehole	870	670	1540			
	Total	**1110**	**1470**	**2580**	**800**	**700**	**1500**
Immobilized Emplacement	Front-end	580	1510	2090			
	Borehole	770	720	1490			
	Total	**1350**	**2230**	**3580**	**990**	**1060**	**2050**

As indicated by the data in the table and figure, the undiscounted life cycle cost of the direct emplacement borehole alternative is $1 billion less than immobilized borehole cost. In the Screening Report the borehole alternatives were considered to be a potentially desirable alternative because of presumed low cost to implement. The low cost was presumed because the borehole approaches typically involve low-technology processes and equipment that would be inexpensive compared to highly specialized MOX fuel fabrication equipment. It turns out the presumptions are incorrect. Two significant factors contribute. First, the borehole site facilities are generic, non-DOE sites, unlike all other alternatives which are accomplished on DOE sites with greater or lesser amounts of infrastructure. As such, large costs are required to develop the infrastructure to support the borehole facilities. Second, whereas the borehole processes are relatively low technology operations, they are processes which still must be performed in expensive Category I plutonium handling facilities.

The immobilized emplacement alternative is much more expensive than the direct emplacement alternative, owing to the large costs associated with the front-end processing, which is in turn due to the larger material throughput processed for the immobilized alternative (approximately 500 MT per year). As indicated in Chapter 3, there is substantially more cost and schedule uncertainty in the direct emplacement alternative due to the difficulty anticipated in acquiring a license for direct emplacement of materials. The licensing analysis is anticipated to be greatly simplified by the use of immobilized forms for plutonium.

(Information previously here was moved to Chapter 6.)

4.5 HYBRID ALTERNATIVES COSTS

Costs for hybrid alternatives in which existing LWR or CANDU reactors effect disposition of approximately 32.5 MT of plutonium and immobilization facilities process the remaining 17.5 MT inventory are shown in Figure 4-5, with supporting detail included in Table 4-5.

Figure 4-5. ***Reactor/Immobilization Hybrids Investment and Life Cycle Costs***

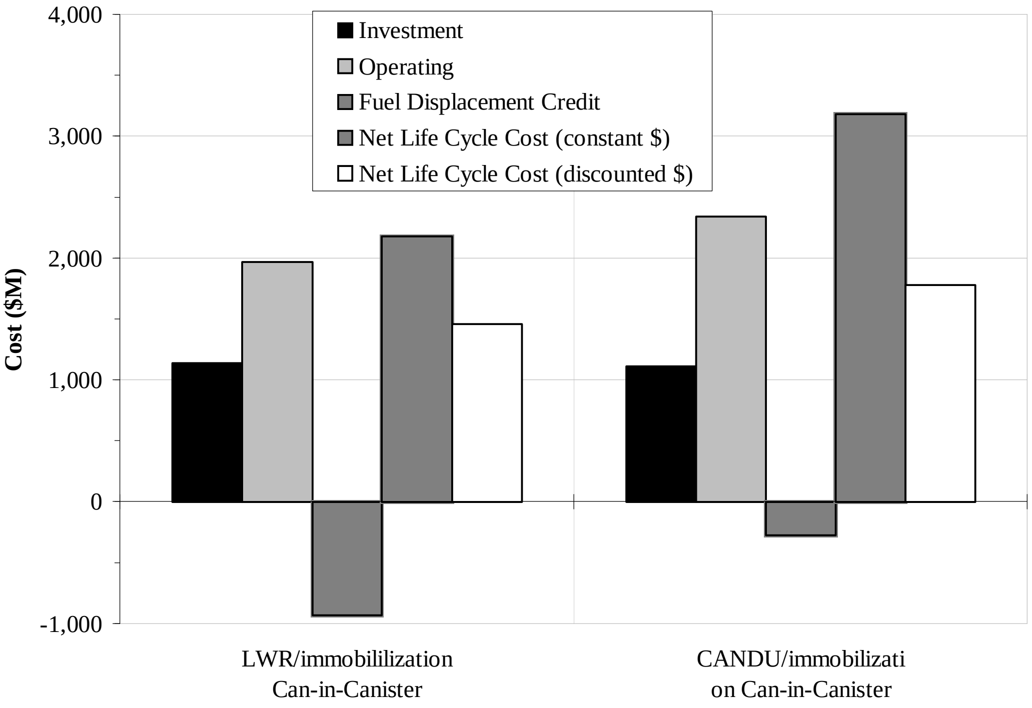


Table 4-5. ***Reactor/Immobilization Hybrid Alternatives Costs***

		Constant $ (millions)				*Discounted $ (millions)*			
Hybrid Alternative	***Facility***	***Investment***	***Operating***	***Fuel Displacement Credit***	***Net Life Cycle Cost***	***Investment***	***Operating***	***Fuel Displacement Credit***	***Net Life Cycle Cost***
Existing LWRs/ Immobilization Can-in-Canister (3 PWRs)	Front-end	360	970	0	1330				
	MOX Fab	360	820 [1]	-930	250				
	Reactor	200	90	0	290				
	Immobilization	220	60	0	280				
	Repository	0	30	0	30				
	Total	**1140**	**1970**	**-930**	**2180**	**820**	**1120**	**-480**	**1460**
CANDU/ Immobilization Can-in-Canister	Front-end	340	980	0	1320				
	MOX Fab	450	1240	-270	1420				
	Reactor	100	30	0	130				
	Immobilization	220	60	0	280				
	Repository	0	30	0	30				
	Total	**1110**	**2340**	**-270**	**3180**	**800**	**1120**	**-140**	**1780**

[1] $140 M of this cost is for the fuel fabricated in Europe.

The front-end facility costs are assumed to be similar to the costs for the can-in-canister alternatives. Because demands on the front-end facility are less than that for the can-in-canister alternative, the estimated costs for the hybrid alternatives are conservative in using the can-in-canister values.

The repository costs for disposal of immobilized waste forms is included in the immobilized operating costs. The repository cost for the spent fuel is a reactor-owner cost, not a cost to the government, and therefore is not included in the repository costs cited in Table 4-9.

In understanding the costs for the immobilization/reactor hybrids, the comparison to the stand-alone reactor alternatives costs is the most illuminating since approximately two-thirds of the plutonium goes the reactor route. In both the CANDU and LWR hybrid alternatives, the investment cost for the hybrid alternatives requires the investment costs for both the reactor and immobilization portions, not double-counting front-end costs for the two alternatives. This represents an approximately $200 million incremental investment for the hybrid alternatives. In the LWR hybrid, the net life cycle costs are approximately $100 million higher than the corresponding stand-alone LWR alternative mostly due to the lower MOX fuel credit. The net life cycle cost for the CANDU hybrid is approximately $70 million more than the stand-alone CANDU alternative. Note that, on an operational cost basis only for the fuel fabrication facility, the market value for LWR MOX fuel exceeds the operational cost for domestically-produced MOX fuel; however, this statement does not hold for CANDU fuel due to the low value of the displaced natural uranium fuel.

(Information previously here was moved to Chapter 6.)

4.6 OVERALL COMPARISON OF ALTERNATIVES COSTS

To facilitate comparisons among alternatives, undiscounted and discounted investment and operating and net life-cycle costs are summarized in Figure 4-6 and 4-7.

Figure 4-6. ***Investment and Operating Costs for Baseline Alternatives (constant $)***[1]

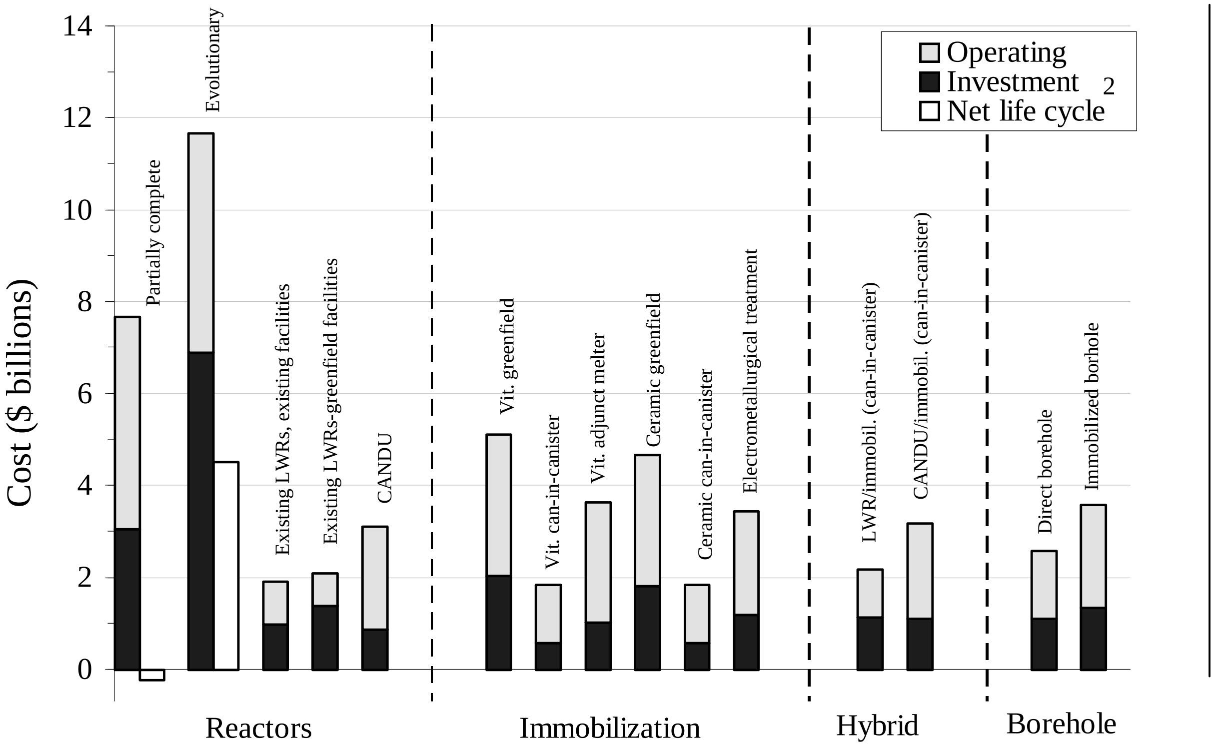
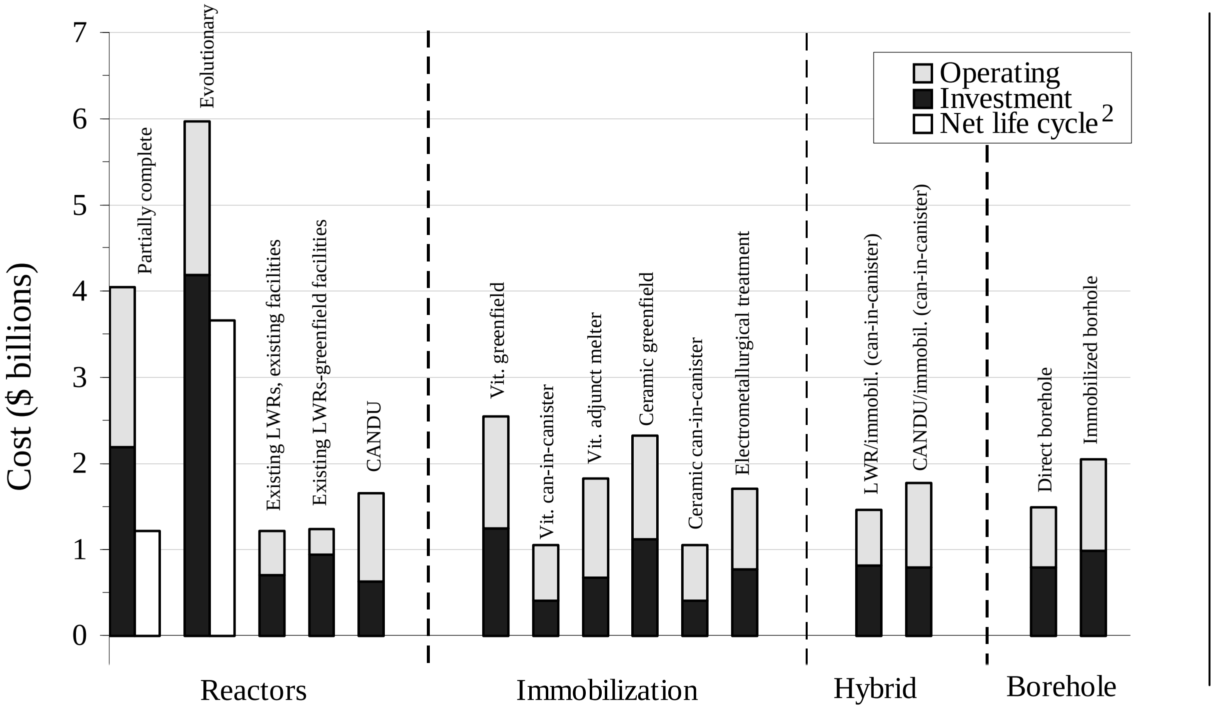


Figure 4-7. ***Investment and Operating Costs for Baseline Alternatives (discounted $)***[1]



[1] The costs are for base case estimates as defined in Chapter 4. Chapter 6 identifies a series of cost uncertainty factors and provides a quantitative estimate of them for many of the alternatives.

[2] For the net life cycle costs of the evolutionary and partially complete reactor alternatives, electricity is sold at $0.029/kWh with all revenues assumed here to accrue to the Government. No acquisition cost or salvage value for the reactors are included. Alternative assumptions are considered in Chapter 6.

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