Advanced Reactor Research and Development Programs

5-Year Plan for Advanced Reactor Activities Under the Energy Policy Act of 1992

DRAFT

May 1994

U.S. Department of Energy

Office of Nuclear Energy

U.S. DEPARTMENT OF ENERGY

OFFICE OF NUCLEAR ENERGY

CIVILIAN REACTOR DEVELOPMENT PROGRAMS

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U.S. DEPARTMENT OF ENERGY
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5-YEAR PLAN FOR ADVANCED REACTOR ACTIVITIES UNDER THE ENERGY POLICY ACT OF 1992

EXECUTIVE SUMMARY

This five-year plan for the Department of Energy's (DOE) Civilian Reactor Development Program is based on both the Department's and the Office of Nuclear Energy's Strategic Plans, as well as the requirements of the Energy Policy Act of 1992 (EPACT). The time frame covered by this Plan is FY 1994 through FY 1998.

Among its other provisions, EPACT codifies the Nuclear Regulatory Commission's (NRC) Part 52 licensing reform rule, which provides for certification of standardized designs, issuance of combined construction and operating licenses, and informal hearings on new nuclear plant construction. The Act also authorizes the NRC to allow interim operation of completed reactors under certain conditions.

In addition, EPACT provides multi-year authorization for DOE's Advanced Light Water Reactor (ALWR) design certification and First-of-a-Kind engineering programs to support commercialization of ALWR reactor designs during the 1990s. The Act also supports programs focused on continued research and development of the Actinide Recycle system and the Modular High-Temperature Gas-cooled Reactor (MHTGR). EPACT also requires the Secretary of Energy to recommend to Congress by 1998 one or both of these technologies for construction of a prototype demonstration reactor.

EPACT subsection 2122(c) requires the Secretary of Energy to update the Office of Nuclear Energy's Five-Year Program Plan annually and to submit such updates to Congress, describing any activities that are behind schedule, any funding shortfalls, and any other circumstances that might affect the ability of the Secretary to meet the goals set forth in subsection 2122(b). In conformance with this requirement, this Plan reflects the Administration's policy to focus on research and development programs that have near-term commercial applications, such as the Advanced Light Water Reactor program, and to place greater budgetary priority on other energy supply and conservation options.

Consistent with EPACT requirements, the ALWR design certification program is designed to achieve NRC pre-certification of four ALWR designs. In addition, for two of these designs, the First-of-a-Kind Engineering (FOAKE) program will provide cost and schedule certainty to the marketplace by ensuring standardization of plant components not covered under the program to achieve NRC design certification.

Design activities for the Advanced Liquid Metal Reactor (ALMR) and MHTGR (now known as the Gas Turbine-Modular Helium Reactor or GT-MHR) are scheduled for termination beginning in 1995, in conformance with the Administration's policy to restrict reactor research to the more near-term advanced light water reactor activities.

Continued support of the Actinide Recycle program is inconsistent with the Administration's position concerning the use of plutonium for civilian power production in the future. Therefore, termination of the Actinide Recycle program is proposed, starting in FY 1994.

In compliance with the Energy Policy Act and the Administration's directives, this Plan details the current mission, relationships, activities, milestone schedule, and resource requirements for each of DOE's civilian advanced reactor research and development programs, as well as the budgetary appropriations approved by the Congress.

Program Mission

DOE's advanced reactor programs are managed through its Office of Nuclear Energy (NE). The primary mission of these programs is to meet the projected future need for new baseload generating capacity by enabling safe, economical nuclear power technologies as an option for the Nation's electric utilities. In addition to EPACT, this mission is based on the Atomic Energy Act of 1954, the Energy Reorganization Act of 1974 (Public Law 93-438), and the DOE Organization Act (Public Law 95-91).

Activities in progress to support this primary mission include: (1) encouraging institutional reform to reduce the initial financial risk of new nuclear plant construction; (2) continuing interaction with the NRC and the public; (3) assisting in research and development of competitive, innovative reactor designs for eventual commercial deployment; (4) ensuring that all nuclear testing and research facilities overseen by NE are operated in a safe and environmentally sound manner; and (5) emphasizing cost-sharing with industry to spread development risks and lower costs.

Program Objectives

To meet the EPACT requirements and fulfill its legislative mandate under current and projected budgetary constraints, the DOE Office of Nuclear Energy has identified several objectives related to the operation of existing nuclear power plants and the development of new, advanced plants as a viable option for near-term commercial application.

These objectives are:

- Assisting utilities in maintaining operation of current nuclear units as long as they can be operated safely and economically.

- Making available to the marketplace certified, standardized advanced light water reactors that meet customer requirements and offer significant advances in safety.

DOE's civilian reactor development programs are now being restructured to focus on Advanced Light Water Reactors that have near-term commercial applications.

Program Milestones

To meet its mission objectives, the Department of Energy has established the following milestones:

Milestone Date	Milestone
(September 1997)	Complete design of two standardized ALWRs.
(December 1997)	Achieve NRC certification of four ALWR designs.

In accordance with the Energy Policy Act of 1992, the Department will carry out its civilian nuclear programs, within budgetary limits, to foster the continued availability of nuclear power as a clean, safe, and economical alternative option for electricity generation.

As an adjunct to current program activities, the Office of Nuclear Energy recommends that long-term nuclear energy research and development needs be examined by an organization such as the National Academy of Science, in consultation with other outside experts.

THE ADVANCED LIGHT WATER REACTOR PROGRAM

THE ADVANCED LIGHT WATER REACTOR PROGRAM

Program Mission

The mission of the Advanced Light Water Reactor (ALWR) program is to make available to the marketplace certified, standardized ALWRs that meet customer requirements and offer significant advances in safety. Successful completion of this mission would enable nuclear power to contribute to projected future electrical generating capacity requirements by 2010. This goal is consistent with the U.S. utility industry and plant vendor goal of obtaining new nuclear powerplant orders later in the 1990s to allow the first new plants to enter service near the turn of the century.

Program Relationships

DOE has coordinated its ALWR activities closely with those of the private sector. All of the ALWR programs are cost-shared with the private sector (e.g., utilities and vendors) to ensure their relevance. In addition, day-to-day management responsibilities for several of the programs are placed with the private sector to ensure a marketplace orientation.

Industry cooperation includes program cost-sharing with U.S. utilities through the Advanced Reactor Corporation (ARC), the Electric Power Research Institute (EPRI), and other utility groups; and with reactor plant designers (ABB Combustion Engineering, General Electric (GE), and Westinghouse). The program also maintains coordination with industry associations such as the Institute of Nuclear Power Operations and the Nuclear Energy Institute, to ensure overall consistency between government and industry approaches to policy issues.

The program utilizes national laboratories, such as those at Oak Ridge, Tennessee, and Sandia, New Mexico, to ensure that their specialized expertise is beneficially applied to the development of ALWRs.

Interagency coordination with the Nuclear Regulatory Commission (NRC) is maintained in areas related to the safety and licensing of current and Advanced Light Water Reactors (ALWRs). This coordination is particularly important in meeting program goals such as the design certification of evolutionary and mid-sized ALWR plants.

Recognizing that effectiveness in design and operational safety are common global concerns, cooperative international programs are maintained with a number of organizations in the Far East, Europe, and in countries of the former Soviet Union. Cooperative arrangements have also been established with several Organization for Economic Cooperation and Development member countries, as well as with the International Atomic Energy Agency.

Planning Assumptions

- The private sector will continue its implementation of the Nuclear Power Oversight Committee Strategic Plan.
- Current cost-sharing arrangements will be maintained with the private sector.
- NRC will maintain its schedule for certifying ALWR designs through 1996 and 1997.

Program Plan

Light water reactors are utilized throughout the world to provide safe, dependable electric power. The ALWR program builds upon this experience by working to incorporate the lessons learned from over three decades of plant

operation into simpler plant designs. Greater simplicity of design will make ALWRs easier to construct and operate and enable a lower core damage probability than current plants.

Major ALWR program elements include:

- Demonstration of an improved regulatory process through certifying standardized, evolutionary ALWR designs that meet utility requirements.
- Development and certification of simpler, standardized, mid-sized ALWR plants with passive/innovative safety features.
- Encouragement of industry-wide plant standardization
- Assistance in resolving institutional and economic regulatory impediments to nuclear power.

These activities are scheduled to be completed by the late 1990s to allow utilities to consider a new plant order for operation around the turn of the century.

ALWR life-cycle costs are expected to be competitive with alternative, base-load technologies, such as coal and natural gas combined-cycle plants. ALWR design standardization is primarily responsible for reducing such costs to below the level of current nuclear powerplants.

Certification of Evolutionary Plants

During the certification process, the NRC performs a complete safety review of a design and, when results are acceptable, certifies the design. A utility can then elect to construct this certified design with a reduced risk of redesign or retrofit after the start of construction.

Two large (1300 MWe) evolutionary ALWR designs, the GE Advanced Boiling Water Reactor (ABWR) and the ABB Combustion Engineering System 80+ Pressurized Water Reactor, have been submitted to the NRC for certification. In addition to building on the experience of currently operating plants, these designs incorporate significant advances in safety, component and systems performance, and instrumentation and controls.

The ABWR and System 80+ designs are currently under intensive review by the NRC. Agreement has been reached with the NRC on the level of design detail required for certification, and agreement on technical issues and acceptance criteria is near. DOE anticipates that the NRC will issue its final design approval for the ABWR and System 80+ during 1994. Certification of the ABWR and System 80+ is expected in 1996.

Passive Plant Development and Certification

The Department of Energy also is collaborating with industry in a program to design and certify two simplified, mid-sized (600 MWe) ALWRs which employ passive safety systems. These plants would require a smaller capital investment and, therefore, involve a reduced financial risk. They also would be more flexible, allowing the incremental matching of supply with growth in demand. In addition, these mid-sized ALWRs offer the prospect for significant simplifications and innovations in design, construction, and operation, all made possible by their reduced size. This, in turn, permits much shorter construction schedules and competitive economics.

These simplified ALWR designs will primarily employ passive features to ensure essential safety functions. Use of these passive features will result in greatly increased time for operator response and an improved level of safety compared to currently operating plants.

Applications for certification of these mid-sized designs, the Westinghouse AP600 and the General Electric Simplified Boiling Water Reactor (SBWR), were submitted to the NRC in mid-1992. Certification is scheduled for 1997.

Standardization

In 1992, DOE initiated a standardization program in which the utility industry is taking a strong leadership role. This cooperative, cost-shared program focuses on completing First-of-a-Kind Engineering (FOAKE) on selected ALWR design concepts. These designs will go beyond the level of detail required for certification and will be sufficiently detailed to provide the cost and schedule certainty necessary to permit the consideration of new nuclear powerplant orders by the marketplace later in the 1990s. This level of FOAKE will be performed generically and applied to all plants of the same design. The design can then serve as the basis for a series of standardized plants.

The ARC has selected two designs for this program, the Westinghouse AP-600 (a 600 MWe PWR) and the General Electric ABWR (a 1300 MWe BWR). Contracts with Westinghouse and General Electric have been signed.

Total costs for this cost-shared program are projected at more than $200 Million. Maximum Federal Government funding for this program is set at $100 Million. Private sector contributions include nearly $50 Million from the utility industry, and more than $100 Million from nuclear suppliers. The program will be completed by 1997.

Institutional and Regulatory Activities

DOE sponsors several programs aimed at improving the institutional and regulatory environment to promote the stability necessary for a new plant order. An improved institutional and regulatory climate requires a stable, predictable safety regulatory process in which final decisions are made with full public participation prior to plant construction. Codification of the NRC's rules for future reactor licensing (10 CFR 52) in the Energy Policy Act of 1992 was a significant step forward in this direction.

Program Schedule

The Energy Policy Act of 1992 provides a multi-year authorization for ALWR design certification and FOAKE programs to support commercialization of ALWR designs by the mid-1990s. The following milestones have been established to achieve the ALWR program:

Design Certification

- Receive NRC design certification of the ABWR and System 80+ designs by August 1996.
- Receive NRC design certification of the AP600 and SBWR designs by December 1997.

Standardization

- Develop key equipment and procurement specifications by July 1995.
- Complete First-of-a-Kind Engineering activities by December 1997.

A detailed ALWR program Milestone Schedule is provided in Figure 1.

Resource Requirements

Annual projected funding (government and nongovernment) required for the ALWR Program to meet the Energy Policy Act milestones is summarized in Figure 2. FY 1993 DOE program funding for the ALWR program was $57.8 Million. Additional DOE funding of $186 Million is required through FY 1998 (see Figure 2). After FY 1998, when NRC-certified, standardized ALWR designs are expected to be available in the marketplace, further research and development is expected to be performed by the private sector, with DOE providing assistance where needed.

Program Progress

- All program activities are underway under agreements with the private sector. Required private sector cost-sharing has been pledged and industry organizations are in place for all programs.

- All certification reviews by the NRC are underway, and certifications for all designs are expected by the end of 1997.

- The standardization program began design-specific activities in early 1993. Completion of the program is scheduled for 1997.

- Enactment of the licensing reform provisions required by the Energy Policy Act of 1992 is expected to provide the regulatory stability required to enable new plant orders.

In summary, all major ALWR elements are expected to be completed in accordance with the EPACT directives.

Contingencies

ALWR Program cost and schedule estimates assume that no major design changes will be required as a result of NRC design reviews. This assumption is based on NRC/industry interactions on the ALWR Utility Requirements Document, which have resolved most of the ALWR technical and safety policy issues. Should unforeseen technical policy issues arise during NRC reviews, program costs, and schedule estimates would have to be reevaluated.

FIGURE 1
ALWR PROGRAM MILESTONE SCHEDULE

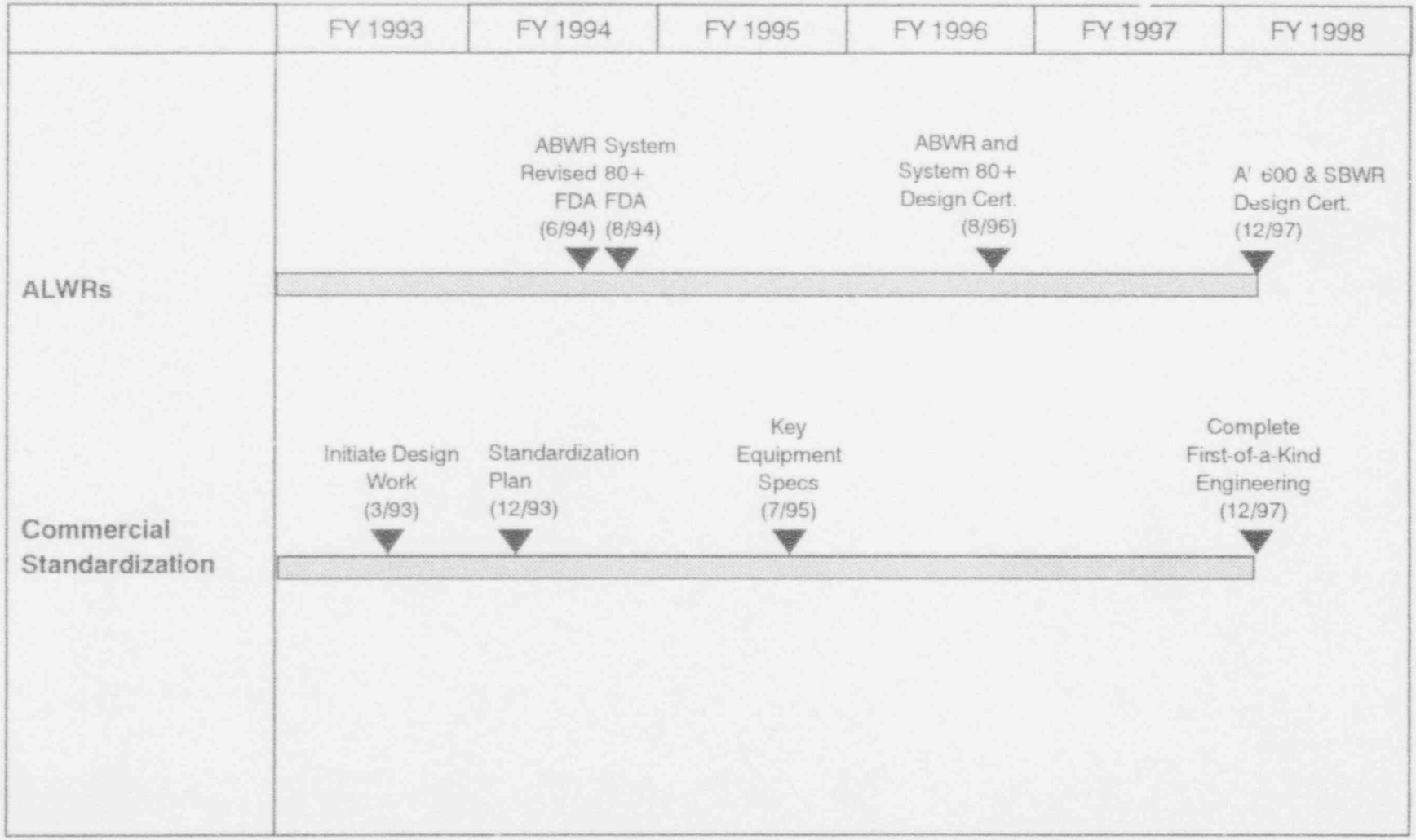
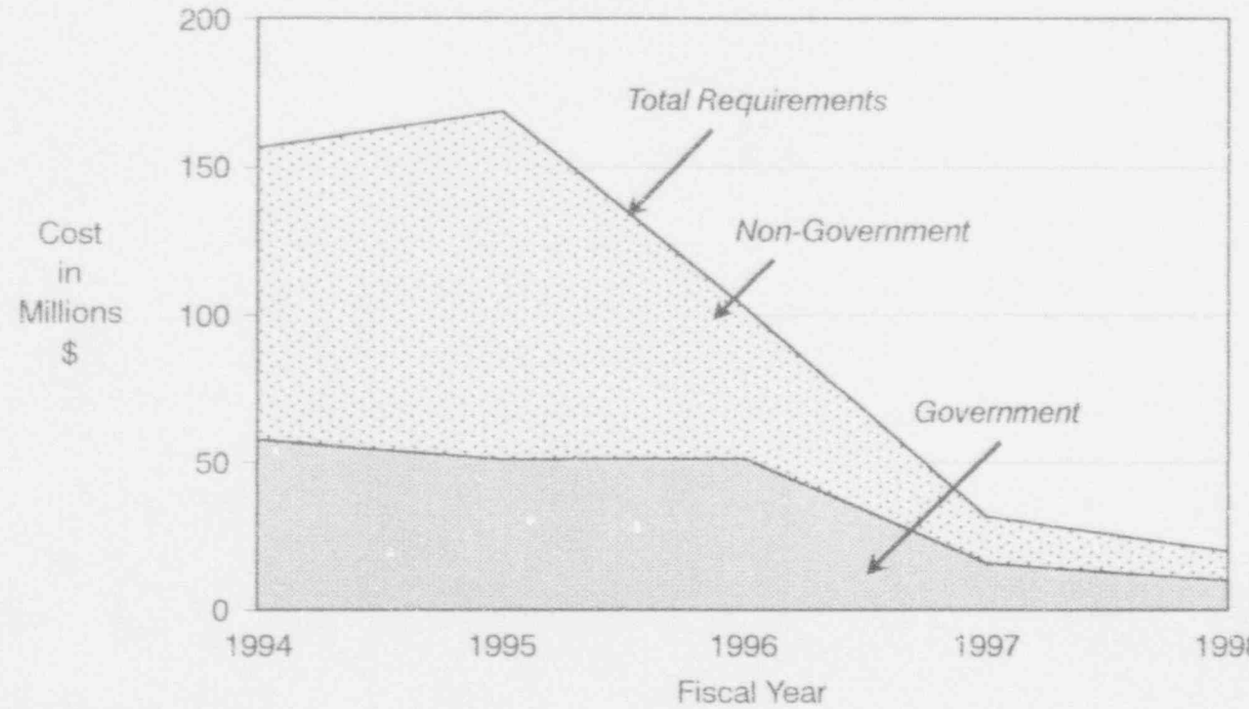


FIGURE 2
ANNUAL ALWR PROGRAM PROJECTED COSTS TO MEET ENERGY POLICY ACT MILESTONES



	1994	1995	1996	1997	1998	TOTAL
Government R&D	57.6	51.0	51.5	15.9	10.0	186.0*
Non-Government:	98.8	117.6	51.5	15.9	10.0	293.8
Total Requirements:	156.4	168.6	103.0	31.8	20.0	479.8

**Figure includes funding for current and advanced reactor safety and licensing support*

THE ACTINIDE RECYCLE PROGRAM

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Program Mission

The mission of the Actinide Recycle program has been to conduct the research, development, and testing activities required to demonstrate by 1997 the technical and economic feasibility of an innovative and highly diversion-resistant nuclear fuel cycle technology. If successfully developed, actinide recycle could significantly contribute to radioactive waste management by producing electricity from material that would otherwise require disposal in the planned geologic repository.

The program has been focused on development of a synergistic system comprised of three technology components: (1) an advanced liquid metal reactor, (2) an integral fast reactor/closed metal fuel cycle processing and fabrication system, and (3) a pyroprocessing system capable of recovering actinide elements from spent Light Water Reactor (LWR) fuel. In addition to providing electric power, this system has the potential to extract the most toxic and long-lived elements (actinides) from LWR spent fuel and to economically recycle this "waste" material as fuel in an integral fast reactor to produce electricity.

The Administration has made a serious review of the Actinide Recycle technology program, including the Integral Fast Reactor and ALMR programs as part of the FY 1995 budget discussions. The Department believes that the program's continuation is inconsistent with the Administrations's position concerning the use of plutonium for civilian power production in the future, and, therefore, has proposed terminating the program in FY 1995.

Termination Justification

Consistent with Presidential Decision Directive 13 of September 27, 1993, which states that the United States does not encourage the civil use of plutonium, the Department has recommended termination of the Actinide Recycle Program. Continuation of the program is inconsistent with the Administration's views concerning the use of plutonium for civil power production. Furthermore, termination of the program is consistent with the Administration's policy to restrict reactor research to the more near-term advanced light water reactor certification activities, placing greater budgetary priority on alternative energy supplies and conservation options.

Program Relationships and Termination Impacts

In conducting the Actinide Recycle program, coordination is maintained between contractors, national laboratories, associations, universities, federal agencies, and foreign participants.

Actinide recycle technologies were being developed as an extension of the metal fuel cycle technology development conducted at Argonne National Laboratory (ANL). ANL had implemented a metal fuel cycle research and development program that includes demonstration in ANL's Fuel Cycle Facility of pyroprocessing technologies that provide efficient actinide recycling and enhanced proliferation-resistance. These actinide recycle technologies utilize pyrochemical processes to extract actinides directly from LWR spent fuel for use as fuel in an integral fast reactor. Other national laboratories, including Oak Ridge National Laboratory (ORNL) and Lawrence Livermore National Laboratory (LLNL), as well as an industrial team led by General Electric Company, were also involved in supporting the Actinide Recycle program.

Independent studies have also been underway, such as the National Academy of Sciences' three-year study (initiated in 1991) to evaluate the impacts of waste partitioning and

transmutation technologies on radioactive waste management, including a review of the actinide recycle system. In addition, Japan has been cooperating with the U.S. on metal fuel cycle demonstration, including actinide recycling. In June 1992, DOE and Japan initiated a cooperative multi-year program to develop LWR spent fuel pyroprocessing. In October 1992, DOE and Japan also extended a cooperative agreement, signed on July 7, 1989, for a joint pyroprocessing development program that includes significant financial and manpower support from Japan.

Concurrently, DOE has been participating in actinide recycle information exchange programs with the Organization for Economic Cooperation and Development's Nuclear Energy Agency, as well as exploring possible enhanced bilateral cooperation with Agency members. Continuing technical exchanges have been conducted with the European Fast Reactor group.

National laboratory and industry participants affected by termination of the Actinide Recycle program include Argonne National Laboratories in Illinois and Idaho, EG&G in Idaho, Lawrence Livermore National Laboratory and the General Electric Company in California. Oak Ridge National Laboratory in Tennessee, and Westinghouse Hanford Company in Washington.

With termination of the Actinide Recycle program, Japanese contracts with CRIEPI, MITSUI, and JAPC would be terminated.

Planning Assumptions

- Termination of the Actinide Recycle program is contingent upon Congressional approval.
- Termination activities must begin by October 1, 1994, in order to minimize termination and severance cost liabilities.
- Congress will provide the FY 1995 termination funding needed to meet the program's close-out obligations.

Program Plan

Program activities will be funded in FY 1994 as authorized and appropriated by Congress. Efforts will continue through September 30 to complete ongoing evaluations, studies, and critical research and development needed to support a technical and economic feasibility evaluation.

Activities currently scheduled for FY 1994 include (1) demonstration of high burnup potential and fuel performance characterization; (2) engineering-scale demonstration of electrorefining prototype equipment at ANL-East; (3) development of a safety data base to support design team interactions with the NRC; and (4) EBR-II core conversion with the uranium-zirconium and uranium-plutonium-zirconium metal fuels.

Orderly program closeout activities will begin by October 1, 1994, contingent on receiving Congressional approval by that date.

Actinide Recycle Development

As of the beginning of 1994, the Actinide Recycle program had investigated several process flow sheets that are considered attractive for processing LWR spent fuel. One that uses lithium as the reducing agent was chosen for the 20-kg process development test that began operation in October 1993.

Actinide Recycle program activities include:

- Completion of small-scale testing with simulated LWR spent fuel;
- Completion of engineering-scale equipment design;

- Preparation of a draft waste qualification strategy; and

- Documentation of the behavior of high-actinide fuel irradiation to less than or equal to 5 atom-percent burnup.

Facilities

The Department will work with Congress to redirect the valuable intellectual and physical resources from this program to support one or more of the Department's higher priority programs. The Administration is committed to mitigating any job loss associated with termination and to utilizing this highly trained workforce.

Termination plans for IFR/LWR Actinide Recycle facilities include the following:

Experimental Breeder Reactor-II (EBR-II)

The EBR-II is a 62.5 MWt, liquid metal-fueled reactor that has been in continuous operation since 1964. This reactor has been used to conduct a variety of test programs, including metal and oxide fuel irradiation tests, reactor safety tests, materials tests, and instrumentation and control tests.

Starting in FY 1995, EBR-II will be shut down, defueled, and placed in an industrially and radiologically safe condition in preparation for transfer of the reactor to the Office of Environmental Restoration and Waste Management (EM) in FY 1999.

Fuel Cycle Facility (FCF)

The FCF is a shielded, hot cell facility that consists of an air-atmosphere hot cell and an argon-atmosphere hot cell. This facility is adjacent to EBR-II and is presently in the final stages of preparation for demonstration of metal fuel processing technology.

The FCF will be used to process EBR-II blanket and driver fuel into an acceptable form for disposal in a long-term geologic repository. Following completion of these fuel processing activities, the FCF will be placed in an industrially and radiologically safe condition.

Analytical Laboratory

The Analytical Laboratory contains six small, shielded hot cells that are used to conduct fuels and materials examinations. This facility is being presently modified to conduct the sample analyses required for processing of EBR-II blanket and driver fuel in the FCF.

Following completion of activities necessary to support the EBR-II blanket and fuel processing in the FCF, the Analytical Laboratory will be placed in an industrially and radiologically safe condition and transferred to EM.

Transient Reactor Test Facility (TREAT)

The TREAT facility is an air-cooled, pulse-type reactor used to simulate postulated reactor transients and transient undercooling events.

The TREAT facility will be defueled, and the reactor building will be placed in an industrially and radiologically safe shutdown condition for transfer to EM in FY 1999.

Hot Fuel Examination Facility (HFEF)

The HFEF consists of an air-atmosphere hot cell and an argon-atmosphere hot cell that provides capabilities for remote assembly, disassembly, and examination of irradiated subassemblies, materials, and other experiments. The HFEF will be placed in an industrially and radiologically safe condition for transfer to EM in FY 1999.

Fuel Manufacturing Facility (FMF)

The FMF consists of materials vaults and fuel fabrication equipment. The facility is used to manufacture driver fuel, control rods, blanket, and experimental assemblies for EBR-II.

The FMF will be utilized to fabricate stainless steel "dummy" subassemblies for insertion into the EBR-II to replace the blanket and fuel subassemblies that are removed for processing. Insertion of these dummy elements is required to maintain EBR-II core integrity during the blanket and fuel handling and removal operations.

Following fabrication of the stainless steel "dummy" subassemblies, the FMF will be placed in an industrially and radiologically safe shutdown condition for transfer to EM in FY 1999.

Actinide Recycle System Reactor Design

The actinide recycle system reactor design effort was in the final stages of advanced conceptual design. The design had evolved over the five-year design period (FY 1989-93) to a passively safe, modular, metal-fueled, actinide-consuming reactor system. International cooperation had provided several million dollars in design research and development. The reactor system had been reviewed by the NRC and the Advisory Committee on Reactor Safeguards.

A favorable "Preapplication Safety Evaluation Report" on the Power Reactor Innovative Small Module (PRISM) design is expected from the NRC in FY 1994. FY 1994 program activities include finalizing the advanced conceptual design to enable a sound technical and economic decision for prototype development and establishing a basis from which a preliminary design phase can be restarted without loss of information. Foreign contribution to research and development efforts will continue in FY 1994, as will interaction with the Nuclear Regulatory Commission.

Program Schedule

Actinide Recycle program activities will continue through FY 1994. The following milestones have been established for the Actinide Recycle program.

IFR Metal Fuel Cycle Development

- Begin process equipment testing in ANL's Fuel Cycle Facility by April 1994.
- Complete Fuel Cycle Facility construction in FY 1994.

LWR Actinide Recycle Development

- Complete design and construction of all components of the 20-kg simulated LWR spent fuel process demonstration facility. Be prepared to initiate hot-operation by the end of FY 1994.

The IFR/Actinide Recycle schedule is provided in Figure 3.

Resource Requirements

FY 1994 research and development funding for the IFR/LWR Actinide Recycle Program totals $30.4 Million. Facility costs total $6.7 Million. Termination costs for FY 1994 total $82.2 Million, which includes $5.7 Million for ALMR design activities.

During FY 1995, the Department will require $28.1 Million to fund personnel salaries and severance pay, as well as environmental restoration obligations. An additional $76.6 Million of termination funds will be required to begin shutdown of attendant facilities.

Figure 4 details the funding requirements for the Actinide Recycle program close out.

Contingencies

During the upcoming months, the Department will develop a proposal to Congress, after extensive consultation on how the valuable intellectual and physical resources from this program can be redirected to support one or more of the Department's higher priority

programs. The Administration is committed to mitigating any job loss associated with termination, and to utilizing this highly trained workforce.

Possible applications include:

- Processing spent DOE reactor fuel to put it into a form suitable for disposal in the repository.

- Testing the feasibility of denaturing weapons-grade plutonium by mixing it with fission products prior to disposal.

- Improving the stability of DOE spent nuclear fuel now in storage.

FIGURE 3
ALMR ACTINIDE RECYCLE PROGRAM MILESTONE SCHEDULE

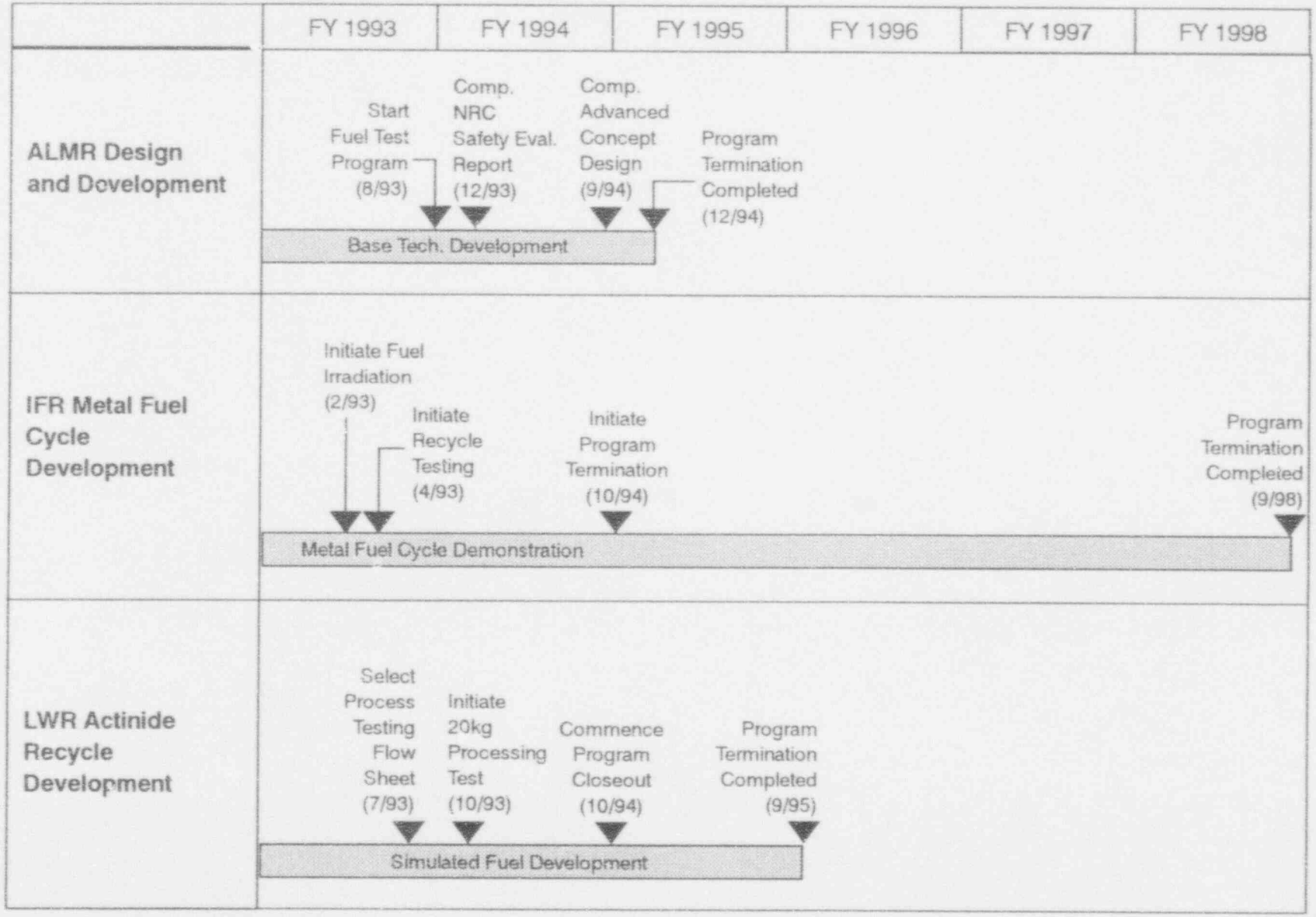
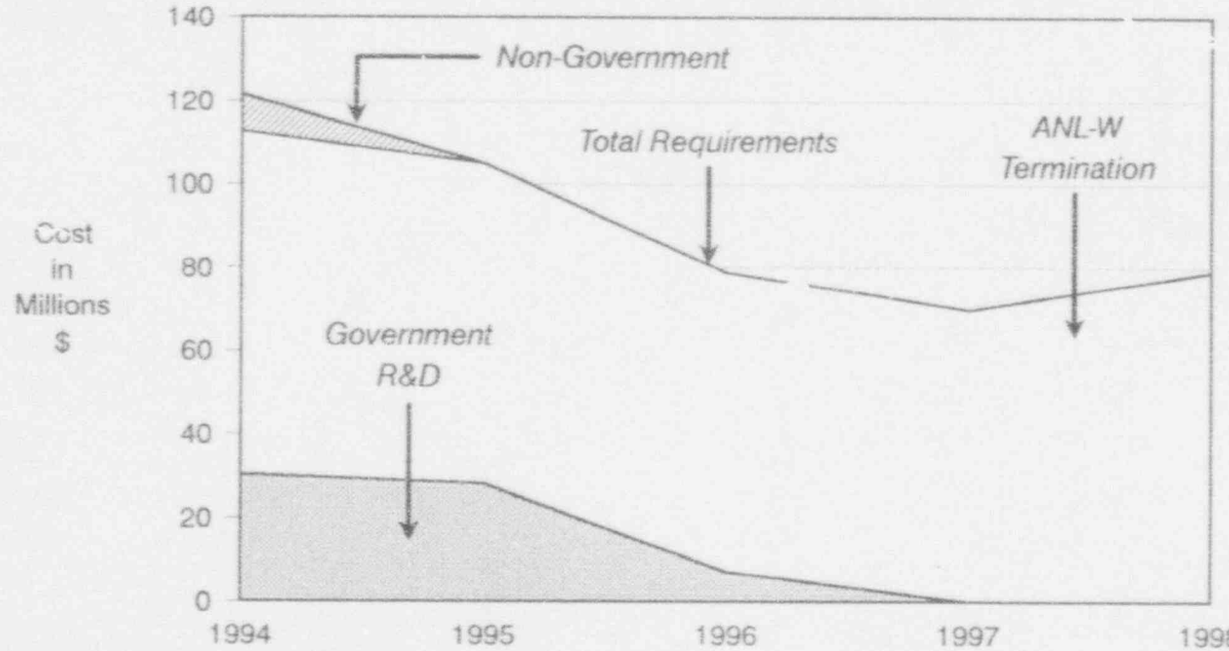


FIGURE 4
ANNUAL PROJECTED COSTS FOR THE ACTINIDE RECYCLE PROGRAM

(Including ANL-E and ANL-W Termination Costs)



	1994	1995	1996	1997	1998	TOTAL
Government R&D:	30.4	28.1	7.1	0	0	65.6
ANL-W Termination Costs	82.2*	76.6	71.6	69.8	78.8	379.0
Total Government	112.6	104.7	78.7	69.8	78.8	444.6
Non-Government	9.0	0	0	0	0	9.0
Total Requirements	121.6	104.7**	78.7	69.8	78.8	453.6

Includes $5.7 million of termination funding to fund ALMR design activities

***The FY 1995 Congressional Budget does not include funding for all required termination activities. $104.7 million will be required.*

THE GAS TURBINE-MODULAR HELIUM REACTOR PROGRAM

THE GAS TURBINE - MODULAR HELIUM REACTOR PROGRAM

Program Mission

The mission of the Gas Turbine-Modular Helium Reactor (GT-MHR) program has been to conduct the design, research, technology development, and testing required to establish the GT-MHR as a cost- and risk-competitive nuclear option for a broad range of owners and operators. This program was a continuation of both worldwide and domestic efforts to bring the safety advantages and high-temperature capabilities of gas reactors to the commercial nuclear industry.

Recent events and studies, however, have indicated that, in this current budgetary climate, such a program must be given a low funding priority. Accordingly, the program is being terminated.

Termination Justification

Termination of the GT-MHR Program is consistent with the President's proposal to curtail long-term nuclear reactor research and development, as well as the Administration's desire to redirect DOE's research and development priorities. To date, the government has spent in excess of $900 Million to advance gas-cooled reactor technology. With the close-out of the New Production Reactor program (NPR) in FY 1993, commonality benefits once obtained from the NPR-Modular High Temperature Gas-Cooled Reactor (MHTGR) design no longer exist. The commercial program must now bear the entire cost of commercial GT-MHR development.

Furthermore, program cost estimates have indicated that the steam-cycle design is not economical or cost-effective. These findings have prompted the program to redirect its efforts towards developing a direct-cycle, gas-turbine variant of the plant design. While preliminary studies have shown that the revised GT-MHR design promises to improve efficiency and economics, it would also result in a more extensive, costly, and uncertain development program. Commercialization and cost-generation estimates completed by the program in November 1993 project that government funding of approximately $800 Million would be required to continue the GT-MHR program through completion of preliminary design in FY 1999. This level of nuclear energy research and development funding is not available in the near term.

A 1992 National Academy of Sciences (NAS) study, "Nuclear Power-Technical and Institutional Options for the Future," concluded that the gas-cooled reactor had a low market potential. This study recommended that, with the exception of fuel particle development, government funding for the gas-cooled reactor program should be discontinued.

In view of present budgetary constraints, fuel development has been designated as a top priority, and funding has been allocated accordingly. Recent fuel irradiation tests of both commercial and NPR design fuels have indicated that fuel coating integrity was about two orders of magnitude less than needed for design objectives. Extensive post-irradiation examinations and analyses have indicated that additional testing and associated funding will be required. The GT-MHR fuel program, once viewed as confirmatory, must now be considered developmental, with attendant schedule and cost uncertainties.

Uncertainties related to waste management concerns, such as disposing and packaging spent GT-MHR fuel, have yet to be addressed and will ultimately escalate established cost estimates.

Consequently, given the current budgetary climate, the GT-MHR's low market potential, estimated high development costs, and the Administration's desire to focus on nuclear research and development that has near-term commercial applications (such as the ALWR), the current GT-MHR program is being terminated, and technical development and deployment should be deferred until a commercial need exists.

Program Relationships and Termination Impacts

The GT-MHR program is involved in cooperative efforts with a number of governmental, private sector, and international organizations.

Private industry contracts for gas-cooled reactor development, initiated in 1986, have been extended through June 1994 in order to evaluate whether to continue with GT-MHR development. The program anticipates that an additional no-cost extension through September 1994 will provide ample time and funds for an orderly contract and program close-out.

Industry participants affected by the program's termination will include corporate entities such as General Atomics and Bechtel National in California, ABB Combustion Engineering in Connecticut, and Stone and Webster in Massachusetts. Gas-Cooled Reactor Associates, a California-based, nonprofit association of utilities and energy users that provides utility/user design requirements and assessments and overall program development support will also be affected. The program's lead technology contractor, Oak Ridge National Laboratory (ORNL), is located in Tennessee.

Program termination will result in termination of program support of nuclear research and applications at the Massachusetts Institute of Technology (MIT), which has been engaged in work on the gas turbine concept since 1984. Smaller efforts at the University of Tennessee and University of West Virginia will also cease.

With the termination of the GT-MHR program, participation in International Atomic Energy Agency-sponsored cooperative research programs and working groups will also terminate. Additionally, a recently extended gas-cooled reactor implementing arrangement between DOE and the Japanese Atomic Energy Research Institute (JAERI) will no longer receive funding.

Planning Assumptions

- Termination of the GT-MHR program is contingent upon Congressional approval.
- Termination activities will begin by October 1, 1994.
- Congress will provide additional FY 1995 termination funds for the Office of Nuclear Energy to fund completion of close-out obligations.

Program Plan

Program activities will be funded at the FY 1994 level approved by Congress. Efforts will continue through September 1994 and will concentrate on completing ongoing evaluations, studies, and conceptual design. Major activities that will be funded include:

- Development of an optimized gas turbine plant layout and power level.
- Evaluation of special development and technology needs, including heat exchangers, rotating machinery, and the code-acceptability of proposed materials.

- Evaluation of fuel failure mechanisms and preparation of a fuel development strategy.

- Support to the NRC in providing required information for completion of the draft Preapplication Safety Evaluation Report (PSER) for the MHTGR scheduled for September 1994.

Orderly program close-out activities will begin on October 1, 1994, contingent on receiving Congressional approval by that date.

Program Schedule

Program activities will continue at a reduced level through September 30, 1994. Contract close-out will begin on October 1, 1994, and will culminate with program termination. Close-out requirements, including document and technology archiving, will be completed in 1995.

Hot cell cleanup at ORNL and fuel line and hot cell cleanup at General Atomics will continue into mid-FY 1995.

The GT-MHR program close-out schedule is provided in Figure 5.

Resource Requirements

FY 1994 funding for the GT-MHR program includes a combination of advanced reactor research and development and termination appropriations totalling $13.5 Million.

To complete termination obligations, an additional $10.5 Million will be required in FY 1995. This will require appropriation of additional FY 1995 termination funds.

Figure 6 and Appendix C detail the funding requirements for an orderly GT-MHR program close-out commencing on October 1, 1994.

Contingencies

The GT-MHR program could continue with Administration and Congressional support. Minimal funding at levels similar to that appropriated in past years, however, would not be sufficient. $800 Million will be required to continue the program through detailed design in FY 1999.

Industry and international organization contributions could offset some projected costs. Significant cost-sharing through detailed design, however, is unlikely.

FIGURE 5
GT-MHR TERMINATION SCHEDULE

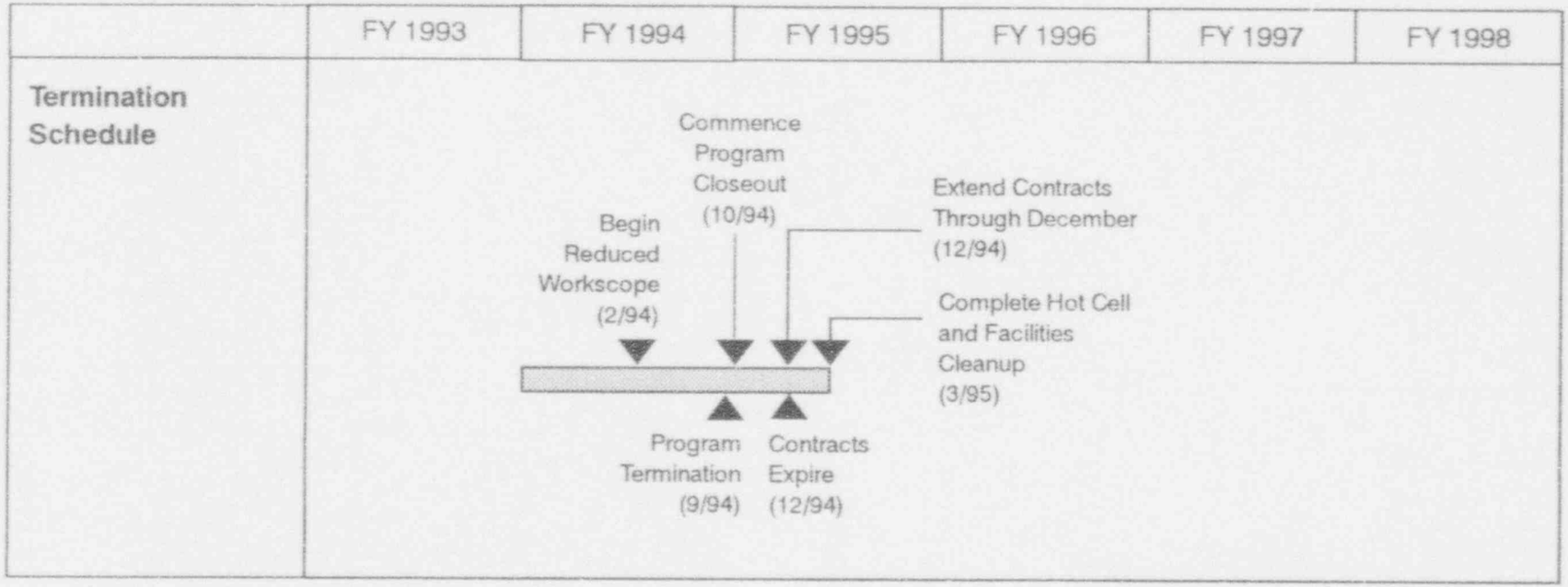
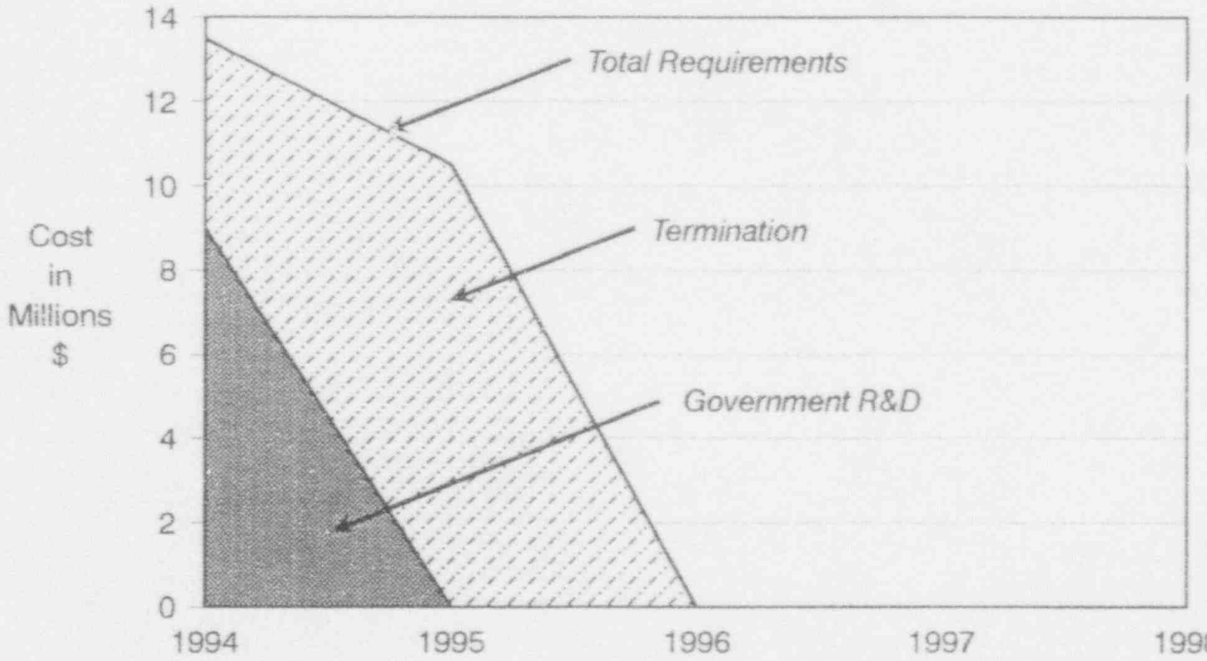


FIGURE 6
GT-MHR PROJECTED COSTS



	1994	1995	1996	1997	1998	TOTAL
Government R&D:	9.0	0	0	0	0	9.0
Termination:	4.5	10.5	0	0	0	15.0
Total Requirements:	13.5*	10.5**	0	0	0	24.0

** Figure reflects reductions for SBIR, M&O pay freeze, and FY 1994 general reduction.*

*** The FY 1995 Congressional Budget does not include funding for termination activities. $10.5 million is required.*

APPENDICES

APPENDIX A
NARRATIVE PROGRAM SUMMARY TABLES

THE ALWR PROGRAM

[ALWR Design Certification]

ACTIVITY	DESCRIPTION	OBJECTIVES	OUTPUT/BENEFITS	PROGRAM PROGRESS
Demonstrate the 10 CFR Part 52 regulatory process by certifying standardized evolutionary ALWR designs with greater safety features.	DOE is co-sponsoring design certification of two evolutionary 1300 MWe plants, the GE ABWR and the Combustion Engineering System 80+.	To obtain certification for the two evolutionary designs.	Make two plants with improved safety available as options for orders and demonstrate the process to certify plant designs.	NRC Final Design Approval of the ABWR is expected in 1994. NRC Final Design Approval of the System 80+ is expected in 1994. An NRC decision on ABWR certification is expected in 1996. An NRC decision on System 80+ certification is expected in 1996.
Develop and certify simpler, standardized, mid-sized ALWR plants with greater safety features.	Development of two advanced mid-sized designs with passive safety systems is underway to enable certification by 1997.	To obtain final design approval and NRC certification. To develop plant designs that meet NRC requirements for ITAAC. To develop plant designs that meet the passive ALWR Utility Requirements Document.	Make two plants with improved safety and lower power levels available as options for orders. Demonstrate the certification process for plants with passive safety features.	Submission of Standard Safety Analysis Reports to the NRC in 1992. NRC decisions on passive plant certifications are expected in 1997.

THE ALWR PROGRAM

[ALWR Design Certification (continued)]

ACTIVITY	DESCRIPTION	OBJECTIVES	OUTPUT/BENEFITS	PROGRAM PROGRESS
Encourage industry-wide plant standardization.	DOE has initiated a First-of-A-Kind engineering program and is working to provide a basis for plant standardization.	To complete design of selected ALWRs, except for site-specific and procurement-specific features.	Enable vendors to market standardized plants on a firm-price basis, using well-justified construction schedules, reducing risk, and providing greater financial certainty.	A cooperative agreement with the U.S. utility industry has been negotiated. Program designs were selected by utilities in 1993. Detailed designs, plant cost estimates, and construction schedules will be completed in 1997.

THE IFR/LWR ACTINIDE RECYCLE PROGRAM

[IFR/Actinide Recycle Termination]

ACTIVITY	DESCRIPTION	OBJECTIVES	OUTPUT/BENEFITS	PROGRAM PROGRESS
Termination	Consistent with the President's policy to focus on nuclear energy research and development that has near term applications, and the Administration's desire to redirect DOE research and development priorities, terminate the IFR/LWR Actinide Recycle program.	Commence an orderly close-out of IFR/LWR Actinide Recycle activities on October 1, 1994, with the objective of terminating the program by September 30, 1995.	Program close-out documentation; organized archived documents; cost saving measure. Consistent with the Administration's position concerning the use of existing plutonium for civilian power production in the future.	Termination efforts are contingent upon Congressional approval.

THE GT-MHR PROGRAM

[GT-MHR Termination Costs]

ACTIVITY	DESCRIPTION	OBJECTIVES	OUTPUT/BENEFITS	PROGRAM PROGRESS
Termination	Consistent with the President's policy to focus on nuclear energy research and development that has near term applications, and the Administration's desire to redirect DOE research and development priorities, terminate the GT-MHR program.	Commence an orderly close-out of GT-MHR activities by October 1, 1994 with the objective of terminating during FY 1995.	Program close-out documentation; organized archived documents; cost saving measure.	Termination efforts are contingent upon Congressional approval.

APPENDIX B
PROGRAM SCHEDULES AND LOGIC

ALWR PROGRAM

[ALWR Design Certification]

MILESTONE	DATE	DESCRIPTION	ACTIVITIES
Submit final General Electric Advanced Boiling Water Reactor SSAR Amendment	1/94	Develop technical, design and licensing documents to support submittal of final SSAR Amendment for ultimate Final Design Approval	• Develop Inspections, Tests, Analyses, and Acceptance Criteria for all plant systems • Develop description of Tier I design to be certified • Resolve open items from NRC reviews • Revise Safety Analysis Report to reflect the above
Submit final Combustion Engineering System 80+ Standard Safety Analysis Report (SSAR) Amendment	2/94	Develop technical, design and licensing documents to support submittal of final SSAR Amendment for ultimate Final Design Approval	• Develop Inspections, Tests, Analyses, and Acceptance Criteria for all plant systems • Develop description of Tier I design to be certified • Resolve open items from NRC reviews • Revise Safety Analysis Report to reflect the above
Receive Nuclear Regulatory Commission Design Certification for the Advanced Boiling Water Reactor Concept	5/96	Finalize certified design and licensing documents. Obtain Final Design Approval. Obtain Nuclear Regulatory Commission certification for the Advanced Boiling Water Reactor	• Complete analyses and calculations • Complete system design description • Complete test demonstration (i.e., passive systems) • Complete Probability Risk Assessment/Reliability, Accessibility, Maintainability, and Inspectability • Complete cost estimate for new construction • Obtain Final Design Approval • Submit Final Safety Analysis Report

ALWR PROGRAM

[ALWR Design Certification (continued)]

MILESTONE	DATE	DESCRIPTION	ACTIVITIES
Receive Nuclear Regulatory Commission Design Certification for the Combustion Engineering System 80+ Concept	8/96	Finalize certified design and licensing documents. Obtain Final Design Approval. Obtain Nuclear Regulatory Commission certification for the System 80+	• Complete analyses and calculations • Complete system design description • Complete test demonstration (i.e., passive systems) • Complete Probability Risk Assessment/Reliability, Accessibility, Maintainability, and Inspectability • Complete cost estimate for new construction • Obtain Final Design Approval • Submit Final Safety Analysis Report
Receive Nuclear Regulatory Commission Design Certification for the Westinghouse AP600 and the General Electric Simplified Boiling Water Reactor	12/97	Develop and finalize technical, design and licensing documents to support submittal of advanced passive plant designs	• Develop Inspections, Tests, Analyses, and Acceptance Criteria for all plant systems • Develop description of Tier I design to be certified • Resolve open items from NRC reviews • Revise Safety Analysis Report to reflect the above • Complete analyses and calculations • Complete system design description • Complete test demonstration (i.e., passive systems) • Complete Probability Risk Assessment/Reliability, Accessibility, Maintainability, and Inspectability • Complete cost estimate for new construction • Obtain Final Design Approval • Submit Final Safety Analysis Report

ALWR PROGRAM

[ALWR Standardization]

MILESTONE	DATE	DESCRIPTION	ACTIVITIES
Initiate Specific Design Work for Standardization	3/93	Complete negotiation and award of the program contracts	• Select major contractors • Develop statement of work • Define test program milestones
Standardization Plan for First-Of-A-Kind Engineering Westinghouse AP-600 GE ABWR	12/93	Define and develop scoping for the design basis, testing programs and interface requirements to support the approach to standardization	• Perform retrospective review of previous plant performance • Determine engineering approaches to simplify design, maintenance, and operational requirements • Target key plant features requiring further analysis, test, or demonstration • Develop milestones to implement standardization plan
Develop Key Equipment/Procurement Specifications	7/95	Perform engineering analyses and calculations and develop drawings to ensure long lead time and critical equipment availability	• Develop functional structural and physical design details for critical systems, structures or components • Examine manufacturing, both domestic and foreign, to ensure infrastructure exists to support design approach • Perform cost and schedule analysis
Design for First-Of-A-Kind Engineering	12/97	Additional development of the technical and design documents and drawings for two ALWR concepts	• Preliminary Nuclear Steam Supply System component design • Complete turbine-generator design • Initial system schematic/logic drawings • Initial major component procurement and other mechanical specifications • Complete containment vessel design • Mechanical Modularization Plan • Electrical and instrumentation/control modularization plan • Complete balance of turbine-generator system design

ACTINIDE RECYCLE PROGRAM

[IFR Metal Fuel Cycle Development]

MILESTONE	DATE	DESCRIPTION	ACTIVITIES
Program Termination	9/98	Complete program termination efforts, including shutdown of facilities, by September 30, 1998.	• Terminate contracts/subcontracts

[LWR Actinide Recycle Development]

MILESTONE	DATE	DESCRIPTION	ACTIVITIES
Initiate 20-kg. process development test.	10/93	This test will utilize simulated LWR spent fuel and is considered a key component in providing thermochemical data for the technical feasibility evaluation milestone.	Provide Data on: • Reduction • Waste streams • Uranium Recovery • Product Purity
Program Termination	9/98	Complete program termination efforts by September 30, 1998.	• Terminate contracts/subcontracts

GT-MHR PROGRAM

MILESTONE	DATE	DESCRIPTION	ACTIVITIES
Extend current contracts through 12/94.	4/94	Extend contracts from June 1994 to December 1994 to allow for conduct of orderly close-out activities.	• DOE OAK initiate no-cost contract extensions.
Commence program close-out	10/94	Commence program close-out activities on October 1, 1994, pending Congressional approval.	• Publish reports. • Archive information. • Cleanup hot cells. • Shut down laboratory facilities. • Cleanup fuel lines. • Dispose of fuel and equipment.
Complete program termination.	12/94	Complete program termination efforts on December, 1994.	• Terminate contracts. • Continue hot cell and fuel line clean up activities.
Complete hot cell and fuel line cleanup activities.	3/95	Complete hot cell cleanup and fuel line cleanup responsibilities at ORNL and General Atomics.	• Dispose of fuel. • Dispose of equipment. • Decommission and decontaminate facilities.

APPENDIX C
RESOURCE REQUIREMENTS

ALWR PROGRAM

COST ACTIVITY	FY 94	FY 95	FY 96	FY 97	FY 98	TOTAL
DESIGN CERTIFICATION COSTS						
Evolutionary Plants	8.7	5.5	1.5	0.0	0.0	15.7
Passive Plants	11.8	6.3	0.0	0.0	0.0	18.1
TOTAL (CERTIFICATION)	**20.5**	**11.8**	**1.5**	**0.0**	**0.0**	**33.8**
FIRST-OF-A-KIND ENGINEERING (FOAKE) COSTS						
Total First-of-a-Kind Engineering Costs	31.7	34.2	25.0	3.9	0.0	94.8
Minimize Premature Plant Retirements	0.0	0.0	20.0	7.0	5.0	32.0
Other Project Costs	5.4	5.0	5.0	5.0	5.0	25.4
TOTAL PROJECT COSTS	**57.6**	**51.0**	**51.5**	**15.9**	**10.0**	**186.0**

ACTINIDE RECYCLE PROGRAM

COST ACTIVITY	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	TOTAL
Actinide Recycle Research and Development	30.4	28.1	7.1	0.0	0.0	65.6
Termination/Operation Costs	82.2	76.6	71.6	69.8	78.8	379.0
TOTAL PROJECT COSTS	**112.6**	**104.7**	**78.7**	**69.8**	**78.8**	**444.6**

GT-MHR PROGRAM

COST ACTIVITY	FY 94	FY 95	FY 96	FY 97	FY 98	TOTAL
R&D COSTS						
Design costs (October 1993 - April 1994)	5.4					3.1
Fuel/Technology Development costs (October 1993 - April 1994)	7.6					4.6
Licensing costs (October 1993 - April 1994)	.5					.1
TOTAL (R&D)	**13.5***					7.8

* Reflects reductions for Small Business Innovative Research, Management and Operating pay freeze, and Fiscal Year 1994 general reduction.

GT-MHR PROGRAM (continued)

COST ACTIVITY	FY 94	FY 95	FY 96	FY 97	FY 98	TOTAL
TERMINATION COSTS						
Disposition of excess equipment		1.2				
Cleanup of GA fuel line/facilities		4.5				
Disposal of irradiated fuel and hot cell cleanup at ORNL		3.0				
COMEDIE material disposal (Note 1)		0.5				
ORNL subcontract closeout (COMEDIE)		0.5				
ORNL subcontract closeout (KFA)		0.2				
ORNL subcontract closeout (MIT)		0.1				
ORNL irradiated graphite disposal		0.1				
ORNL laboratory shutdown (Note 2)		0.2				
Report publication		0.2				
TOTAL (TERMINATION)		10.5*				

Note 1: Materials from COMEDIE BD-1 experiment will be returned to the U.S. from CENG in France for packaging and disposal.

Note 2: Creep laboratories in Buildings 2011 and 4500S, Materials Aging laboratory in Building 4500S

* The FY 1995 Congressional Budget does not include funding for termination activities. $10.5 Million is required.

APPENDIX D

ACRONYMS LIST

ABWR	Advanced Boiling Water Reactor
ADM	Action Description Memorandum
ALMR	Advanced Liquid Metal Reactor
ALWR	Advanced Light Water Reactor
ANL	Argonne National Laboratory
APWR	Advanced Pressurized Water Reactor
ARC	Advanced Reactor Corporation
CE	ABB Combustion Engineering
CENG	Centre d'Etudes Nucleaire de Grenoble
CDD	Certified Design Description
CY	Calendar Year
DEIS	Draft Environmental Impact Statement
DOE	Department of Energy
EBR-II	Experimental Breeder Reactor-II
EIS	Environmental Impact Statement
EPRI	Electric Power Research Institute
ER	Environmental Report
FCF	Fuel Cycle Facility
FDA	Final Design Approval
FOAKE	First-of-a-Kind Engineering
FSAR	Final Safety Analysis Report
FY	Fiscal Year
GCRA	Gas-Cooled Reactor Associates
GE	General Electric Corporation
HTGR	High-Temperature Gas-Cooled Reactor
IAEA	International Atomic Energy Agency
IFR	Integral Fast Reactor
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
Kg	Kilogram
LWR	Light Water Reactor
MHTGR	Modular High-Temperature Gas-Cooled Reactor
MIT	Massachusetts Institute of Technology
M&O	Management and Operating
MWe	Megawatts Electric
NE	Office of Nuclear Energy
NEPA	National Environmental Policy Act
NES	National Energy Strategy
NOI	Notice of Intent
NPR	New Production Reactor
NRC	Nuclear Regulatory Commission
OAK	Oakland Operations Office
ORNL	Oak Ridge National Laboratory
PDA	Preliminary Design Approval

ACRONYMS LIST (continued)

PEIS	Programmatic Environmental Impact Statement
PIE	Post Irradiation Examination
PSAR	Preliminary Safety Analysis Report
PSER	Preapplication Safety Evaluation Report
PSID	Preliminary Safety Identification Document
QA	Quality Assurance
R&D	Research and Development
RCCS	Reactor Cavity Cooling System
RFP	Request for Proposals
SAR	Safety Analysis Report
SBIR	Small Business Innovative Research
SBWR	Simplified Boiling Water Reactor
SER	Safety Evaluation Report
SSAR	Standard Safety Analysis Report
TDP	Technology Development Plan
TREAT	Transient Reactor Test (Facility)