CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

The United States has declared 38.2 metric tons of weapons-grade plutonium surplus to national security needs.[1] Additional inventories of plutonium are expected to bring the total amount of plutonium that is surplus to approximately 50 metric tons. The President has directed that placing the surplus weapons-usable plutonium in a form that provides a high degree of proliferation resistance[2] is a national policy.[3] In their joint declaration from the April 1996 Moscow Nuclear Safety Summit, the leaders of the seven largest industrial countries and the Russian Federation endorsed the need to render the surplus fissile materials (both highly enriched uranium and plutonium) in Russia and the United States to a high degree of proliferation resistance:

> [Surplus fissile material needs to be] safety managed and transformed into spent fuel or other forms equally unusable for nuclear weapons.[4]

To establish a framework for selecting plutonium disposition options which would achieve a high degree of proliferation resistance, the National Academy of Sciences (NAS) reviewed a number of options and concluded that the national objective should be to make the surplus weapons-grade "plutonium roughly as inaccessible for weapons use as the much larger and growing quantity of plutonium that exists in spent fuel from commercial reactors,"[5] a state it defined as the *spent fuel standard*. The Department of Energy (DOE) has enhanced this statement to read:

DOE Spent Fuel Standard
A concept to make the plutonium as unattractive and inaccessible for retrieval and weapons use as the residual plutonium in the spent fuel from commercial reactors.

[1] President Clinton's March 1, 1995, Address to the Nixon for Peace and Freedom Policy Conference and the Department of Energy Openness Initiative, February 6, 1996.

[2] Definitions of key terms are provided in Appendix B: Acronyms and Glossary.

[3] Press Release from the Office of the Press Secretary, The White House, "Nonproliferation and Export Control Policy," September 27, 1993.

[4] Joint Declaration from Moscow Nuclear Safety Summit, April 20, 1996.

[5] National Academy of Sciences, Committee on International Security and Arms Control, Management and Disposition of Excess Weapons Plutonium, National Academy Press, Washington, DC, 1994.

The DOE enhancement makes explicit the concept of material attractiveness, which was implicit in the NAS usage of the term. The spent fuel standard is not a specification-type standard. It encompasses a range of barriers which deter accessibility to and use of plutonium, including such barriers as a radiation field, dilution, inaccessible location, and size and weight. In the aggregate, these barriers achieve a degree of inaccessibility and a difficulty for extraction of plutonium comparable to that of plutonium in "typical" commercial spent fuel. Once having achieved the spent fuel standard, the formerly weapons-usable plutonium is rendered no more attractive for use in nuclear weapons than the much larger and growing inventory of plutonium in commercial spent fuel.

The Interagency Working Group on Plutonium Disposition was tasked by the National Security Council with the comprehensive review of long-term options for plutonium disposition.[6] The DOE has the technical lead for this interagency study. Building on the NAS work, the DOE completed a *screening process* in March 1995[7] in which a large set of proposed, conceptual options for the disposition of plutonium were evaluated. The options that remained after the screening process were identified as reasonable alternatives and have been analyzed in the Draft Programmatic Environmental Impact Statement (PEIS)[8].

1.2 DOE TECHNICAL APPROACH

The plutonium disposition alternatives discussed in this report fall into one of three *categories o*r combinations of them: reactor, immobilization, or deep borehole. Each alternative was defined for analysis as the beginning-to-end set of operations (e.g., from surplus plutonium to geologic disposal) necessary to address all of the surplus weapons-usable plutonium. Several of the alternatives can be implemented in a variety of ways that have significant differences in technical, economic, and/or schedule performance. These different implementation approaches are referred to as "variants" in this report. Hybrid approaches that combine different categories of technologies were also analyzed.

As the agency responsible for the management of special nuclear materials, the DOE has the technical lead for the study of plutonium disposition. The DOE has pursued a series of actions designed to enhance the technical understanding of the alternatives and to provide for implementation. These include:

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[6] Press Release from the Office of the Press Secretary, The White House, "Nonproliferation and Export Control Policy," September 27, 1993.

[7] U.S. Department of Energy, DOE/MD-0002, "Summary Report of The Screening Process, March 29, 1995. Referred to as "The Screening Report" in this document.

[8] U.S. Department of Energy, DOE/EIS-0229-D, "Storage and Disposition of Weapons-Usable Fissile Materials, Draft Programmatic Environmental Impact Statement," February 1996.

1. Defining the alternatives in sufficient detail to permit technical assessments to be performed.
2. Analyzing the alternatives with respect to technical, cost, and schedule criteria.
3. Performing experimental and developmental work to enhance the knowledge base of plutonium disposition.
4. Performing joint studies and joint experimental work with Russian counterparts.

For the first two actions, the data for each of the categories of alternatives were generated by one of three *Alternative Teams* (one for each category) which were composed of personnel from the national laboratories, contractors, and DOE. These personnel provided the expertise to represent all the technologies necessary to implement an alternative from its inception to its completion. These Alternative Teams were responsible for defining and analyzing each alternative in sufficient detail to allow comparative assessments of the alternatives by DOE.

The Alternative Teams defined and developed the network of operations that could be utilized to accomplish the disposition of material at a much greater level of detail than that used for either the Screening Report or the NAS Report. The following information was assembled for each of the alternatives analyzed:[9]

- Block flow diagrams describing process steps for all operations.
- Lists of major equipment and facilities to accomplish functions.
- Mass balance and rate data for unit operations and facilities.
- Sketches of equipment layouts and plot plans.
- Reviews of regulatory and operational considerations for facilities.
- Estimates of facility sizes, personnel requirements, and facility infrastructure requirements.
- Identification of balance of plant requirements.

For the third action, the DOE has been actively engaged in experimental activities to advance the understanding of the technologies. These experimental activities include, but are not limited to:

- Development of a prototype process for extracting plutonium from weapons components.
- Fabricating fuel pellets using weapons-grade plutonium.
- Engineering-scale fabrication of ceramic waste forms with plutonium.

[9] Specific engineering data are presented in the Alternative Team Summary Reports (See References).

- Full-scale "cold" (i.e., without any radionuclides) demonstration of a glass immobilization concept.

The results of the fourth action is a joint U.S. and Russian published study covering the technologies of long-term storage, plutonium conversion and stabilization, geologic disposal, immobilization, water-cooled reactors and fast reactors, and the economic analysis and nonproliferation issues associated with these studies.