COMMENTS ON THE DEPARTMENT OF ENERGY'S
STORAGE AND DISPOSITION OF WEAPONS-USABLE FISSILE MATERIALS
DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Nuclear Control Institute

June 7, 1996

EXECUTIVE SUMMARY

Non-Proliferation Issues

• The nonproliferation analysis is an integral element of the screening criteria and decisions made in preparing the DPEIS, and should therefore be made a formal part of the PEIS, rather than the subject of a separate process. | 1/01.06.00

• The Secretary of Energy should extend the public comment period until 45 days after all relevant support documents, including the cost and non-proliferation analyses, are made publicly available. | 2/08.01.00

• The 1994 NAS study on the disposition of excess weapon plutonium proposed three proliferation risk factors for use in comparing plutonium-disposition options: risk of theft; risk of reversal; and impact on arms reduction. These criteria should be incorporated into the PEIS's non-proliferation analysis. | 3/01.06.00

• Judged by each of these criteria, the option of irradiating weapons plutonium in nuclear reactors (the MOX option) poses far greater proliferation risks than the option of vitrifying plutonium with highly radioactive waste (the VHLW option).

• The MOX option presents a greater risk of diversion primarily because of the fuel-fabrication stage, a process that is difficult to safeguard effectively. Such uncertain verification could severely limit the trust nations place in an international nuclear arms-reductions and non-proliferation regime predicated upon recycling warhead plutonium as fuel for reactors. | 4/01.06.00

• The DPEIS fails to consider the "can-in-a-canister" vitrification option, now being developed at Savannah River and Livermore, despite the great promise it has shown. It must receive specific analysis and consideration in the PEIS. | 5/01.02.00

• The proliferation resistance of the final waste forms largely determines the potential reversibility of plutonium disposition, but the DPEIS fails to examine these issues. A detailed comparative analysis of plutonium retrievability from spent MOX fuel and immobilized glass and ceramic waste forms must be included. | 6/01.06.00

M-281

01 06 00 Comment Number 1

Both the PEIS and the nonproliferation analysis document will be used, along with cost, schedule, and technical analyses in the decisionmaking process, to support the ROD.

08 01 00 Comment Number 2

At the request of several organizations and individuals, the public comment period was extended to a total of 92 days. The documents related to technical, cost, and schedule analyses were made available to the public beginning in July 1996. The nonproliferation analysis was made available to the public beginning in October 1996. These analyses will be considered along with the PEIS by the decisionmaker in reaching the ROD. The public had the opportunity to provide input on the studies before the ROD.

01 06 00 Comment Number 3

The purpose of the Proposed Action is, in part, to establish the technical and program infrastructure that will enable the United States to take unilateral action or negotiate reciprocal actions with other nations for the disposition of surplus weapons-usable Pu. This PEIS addresses the environmental impacts of the reasonable alternatives for DOE's Proposed Action. Analyses of the cost, schedule, technical, and nonproliferation policy impacts are described in separate documents and will be considered in DOE's decision. These documents were made available for public review beginning in late July and October 1996. DOE also conducted a series of public meetings, prior to the issuance of the Final PEIS, to discuss the nonproliferation analysis, *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Materials Storage and Plutonium Disposition Alternatives*, as it relates to the Proposed Action and alternatives.

The analysis of the nonproliferation impacts examines, among other things, the risk of theft, risk of reversal, and arms reduction impacts for the various Reactor Alternatives using MOX fuel and for the Immobilization Alternatives.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 2 OF 47

• Isotopic composition of the residual plutonium in the final waste forms is an inappropriate criterion by which to assess proliferation risks because it perpetuates a dangerous myth that reactor-grade plutonium cannot be used to make workable weapons. The ability to construct a weapon from reactor-grade plutonium was demonstrated decades ago. *It is dangerous even to consider it an open question.* Isotopic degradation does not pose a substantial barrier to re-militarization of warhead plutonium, and therefore does not constitute a compelling argument in favor of the MOX option—a conclusion shared by the 1995 NAS study. 7/01.06.00

• The MOX option would clearly encourage the civil use of plutonium. The U.S. Government would be engaging in MOX activities for the first time on a commercial scale, legitimizing the use of MOX in civil nuclear power programs. Such a sea change in U.S. policy would confuse and complicate U.S. non-proliferation diplomacy. It would send the wrong signal to Western Europe, Japan, and other non-nuclear-weapon states. 8/01.06.00

• The MOX option sends the wrong fuel cycle policy signal in three ways. First, the MOX option effectively declares that plutonium has an asset value, and that the energy contained within it should be viewed as a national asset. Second, the MOX option suggests that a plutonium fuel cycle can be effectively safeguarded, and the use of MOX for weapons plutonium disposition would surely be cited by plutonium advocates as a government "seal of approval" on the process. Third, the MOX option would be portrayed as giving credibility to the claim that plutonium recycle in light-water reactors (LWRs) is essential to nuclear waste management. 9/01.06.00

• While we strongly favor the immobilization options generally over the reactor options, we do not support all the immobilization options. We strongly oppose the electrometallurgical treatment alternative ("pyroprocessing"). This opposition is supported by the conclusions of studies by the National Academy of Sciences, and even DOE's own internal memo. 10/08.03.01

Transportation Security Issues

• The selection of any reactor disposition option will increase transportation risks by adding two extra transportation steps to the disposition process. Weapons-grade plutonium will have to be transported from a plutonium conversion facility to a MOX fuel fabrication plant. MOX fuel would be sent from the fuel fabrication plant to a reactor site or sites. 11/10.00.00

• Transport risks would increase even more if a decision were made to fabricate MOX fuel in Europe, pending construction of a domestic fuel fabrication plant. This scenario would require trans-Atlantic sea shipments of weapons-grade plutonium and unirradiated MOX reactor fuel. 12/10.02.00

• Any of the immobilization options would require less transportation of weapons-usable materials and thereby reduce safety and security risks, a conclusion shared by the 13/08.03.01

M-281

01 06 00 Comment Number 4

Appropriate safeguards and security considerations will be given to the MOX facility during the development of the design, or selection of an existing facility, and during the operation of the facility. These considerations will include the capability for material accountability and appropriate protection of the various forms of the material throughout the fuel fabrication process. As noted in the nonproliferation analysis, MOX fuel fabrication poses a potential security and diversion risk, which must be addressed with enhanced security.

01 02 00 Comment Number 5

The can-in-canister concept is included as a variant under the Vitrification Alternative for surplus Pu disposition. A more detailed discussion of this process appears in Section 2.4.4 and Appendix O of the Final PEIS as a result of comments received.

01 06 00 Comment Number 6

One of the goals of materials disposition is to make the Pu as inaccessible and unattractive for weapons use as the residual Pu contained in commercial nuclear spent fuel (that is, the Spent Fuel Standard). The Pu contained in spent MOX fuel or in an immobilized glass or ceramic form meets the Spent Fuel Standard. The proliferation resistance of the final MOX spent fuel and immobilized forms are compared for the various alternatives and variations in DOE's nonproliferation study, *Draft Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Plutonium Disposition Alternatives*, which was made available for public review beginning in October 1996. DOE also conducted a series of public meetings, prior to the issuance of the Final PEIS, to discuss the analysis of the Nonproliferation Policy as it relates to the disposition and storage and alternatives. The proliferation analyses, along with the PEIS, public comments, and cost, schedule, and technical analyses will be part of the decisionmaking process to support the ROD.

1995 NAS study. | 13/08.03.01 cont.

• There should be an explicit requirement for an armed military escort for U.S. sea shipments of weapons-grade plutonium and mixed-oxide reactor fuel fabricated from it. The DPEIS needs to state publicly what level of security will be required for shipments of plutonium and MOX. Anything less than an armed military escort should be unacceptable. | 14/13.00.00

• The DPEIS does not discuss the security arrangements for sea shipments of plutonium or MOX reactor fuel. Some aspects of these arrangements can and should be made a part of the public record and subject to independent evaluation.

Transportation Safety Issues

• No air shipments of plutonium or MOX should be allowed, given that a crashworthy air-shipment cask has not been developed for these materials. | 15/10.00.00

• The DPEIS understates the environmental hazards of transporting radioactive material by embracing the current international ("Type B") transport standards and assigning a low probability to an accident that could result in a breach of the cask. The DPEIS disregards recent expert reports that challenge the adequacy of the current international standards, as well as ongoing initiatives within the IAEA and the International Maritime Organization (IMO) to re-evaluate these standards in the context of historical data about accident conditions. The DPEIS's analysis is cursory and outdated, and must be revised to take into account the most recent studies and the ongoing IAEA and IMO re-evaluations of these casks. | 16/10.02.00

• Given the amounts of plutonium and MOX that could be transported for disposition, it would be prudent to test the shipping casks to failure and to evaluate the findings in the PEIS. | 17/10.00.00

Economic Issues

• Like the non-proliferation analysis, the cost analysis of plutonium disposition options now being prepared by Oak Ridge National Laboratory must be integrated into the NEPA decision-making process. | 18/08.00.00

• The cost analysis must include all costs of the various disposition options, including subsidies being demanded by nuclear electrical utilities that have expressed interest in using weapons-plutonium MOX fuel.

• Cost comparisons for the different plutonium disposition options should also reflect the cost of security requirements for sea shipments. | 19/07.02.00

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M-281

01 06 00 Comment Number 7

Although it may be possible to make a nuclear weapon from spent commercial reactor fuel, it can only be done with a great deal of difficulty by individuals with extensive experience in handling and processing nuclear materials. The disposition of weapons-usable Pu through the use of MOX fuel in LWRs creates a radiological barrier that makes the Pu as difficult to retrieve and reuse in weapons as Pu in spent commercial reactor fuel. The use of this technology approach would allow for the Pu to be disposed of in a geologic repository the same as commercial reactor fuel.

01 06 00 Comment Number 8

The President's Nonproliferation Policy says the United States will not recycle Pu. Burning weapons-usable Pu in reactors does not utilize the recycling process because the Pu in the spent fuel from this process will not be extracted for reuse in new fuel. This is consistent with U.S. policy since no Pu is being recycled. After a once-through fuel cycle, the Pu would be converted to a nonproliferation form as spent reactor fuel.

01 06 00 Comment Number 9

Converting surplus Pu into MOX fuel is not the end state. The end state is to use the MOX fuel in a reactor, so that after irradiation it meets the Spent Fuel Standard for proliferation resistance. While the Pu is in the MOX fuel form, it would be subject to high standards of safeguard and security.

While the PEIS discusses the generation of spent fuel as an indirect result of potential disposition actions, any subsequent reprocessing and extraction of Pu from that spent fuel is not being proposed by DOE and is beyond the fundamental nonproliferation purpose of the disposition effort. The PEIS evaluates disposition of surplus weapons Pu through use in MOX fuel, but does not further propose or evaluate reprocessing of the spent fuel, and does not suggest or propose reprocessing for the management or disposition of the spent fuel.

Plutonium forms that are suitable for conversion to MOX fuel would have an energy value. However, the alternatives utilizing surplus weapons-usable Pu

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 4 OF 47

I. Introduction

The Nuclear Control Institute ("NCI") is a non-profit policy research group that seeks to increase understanding in the U.S. and other countries of proliferation and terrorism risks associated with civilian uses of nuclear-weapon materials—plutonium and highly enriched uranium. NCI is concerned that certain plutonium-disposition options considered in the Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement ("DPEIS")[1] contribute to those risks.

The Department of Energy (DOE) proposes that a disposition strategy be implemented for the 38.2 metric tons of U.S. weapon-usable plutonium that has been declared surplus, as well as any additional material designated as surplus in the future. This strategy will entail rendering such weapon-usable plutonium as inaccessible and unattractive for weapons use as the plutonium contained in spent nuclear fuel from commercial power reactors, a criterion known as the "spent fuel standard." The objectives of this approach are to strengthen the irreversibility of nuclear arms reductions and to reduce the risks of diversion or theft of the material.

NCI is concerned, however, that arms-reduction and non-proliferation objectives will be undercut if surplus plutonium is used as fuel in nuclear power reactors (the MOX option) rather than directly disposed of in waste (the vitrification option). We are also concerned with issues associated with environmental safety and health, transportation safety and security, economics, legal and regulatory matters, and fulfillment of DOE obligations under the National Environmental Policy Act (NEPA). All these concerns are elaborated in this set of comments, with the exception of environmental safety and health issues, which are addressed in a separate set of comments prepared by Dr. Edwin Lyman, scientific director of the Nuclear Control Institute.[2]

II. Non-Proliferation and Cost Analyses Must Be Included in DPEIS

Two key DOE analyses for use in consideration of plutonium disposition alternatives are not yet completed. DOE is still preparing a cost analysis and a non-proliferation analysis of disposition options. At the April 18 public hearing on the DPEIS, Greg Rudy, head of the Office of Fissile Material Disposition, stated that those analyses would eventually be made available to the public when completed, but not prior to the end of the comment period, then scheduled to end on May 7. At the request of NCI and several other 18/08.00.00 cont.

[1] Office of Fissile Materials Disposition, U.S. Department of Energy, Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement, DOE/EIS-0229-D, February 1996, Volumes I. II. III. and summary (hereafter referred to as "DPEIS").

[2] Dr. Edwin Lyman, "Public and Occupational Health and Safety Impacts of Plutonium Disposition Alternatives," Nuclear Control Institute, June 7, 1996.

M-281

for fabrication of MOX fuel and burning in reactors are considered reasonable since converting the material to spent fuel meets the Spent Fuel Standard.

The Department of Energy is confident that the utilization of MOX fuel can be effectively safeguarded. Appropriate measures will be taken to provide this assurance. Further, the U.S. fuel cycle policy is unchanged. The Pu would be consumed in a reactor using a once-through fuel cycle, then disposed of as spent nuclear fuel. No reprocessing would be involved in surplus Pu disposition, consistent with the President's Nonproliferation Policy.

08 03 01 Comment Number 10

The Department of Energy acknowledges the commentor's opposition to the Electrometallurgical Treatment Alternative. Decisions on disposition of weapons-usable fissile materials will be based upon environmental analyses, technical and economic studies, national policy considerations, and public input.

10 00 00 Comment Number 11

The human health risks of material transportations associated with the proposed Pu storage and disposition alternatives are evaluated and presented in Section 4.4 of this PEIS. The more detailed description of the methodology and supporting data for the analysis is presented in the Appendix G. Transportation of radioactive materials between sites includes health risks for both normal operations and accident conditions to the public and workers.

10 02 00 Comment Number 12

According to results calculated by the RADTRAN code, the highest number of total potential fatalities from the transportation of materials from lag storage to fuel fabrication and then to a reactor site is 4.16 for MOX fuel fabrication in the United States. For MOX fuel fabrication in Europe, the number of potential fatalities for transportation would be 4.62. Risk differences between the two MOX fuel fabrication options (that is, the United States vs. Europe) are very small for transportation of all stages involved. The

public-interest groups and stakeholders,[3] the comment period was extended until June 7, but DOE said that "while [DOE] does not intend to incorporate such [non-proliferation and cost] reports within the PEIS, they will be made available for public review this summer."[4] Mr. Rudy asserted that these analyses are not required for inclusion in the PEIS process which focuses on environmental issues.

This is an inappropriately narrow view of the scope of programmatic environmental impact statements. Previous EIS's, such as the spent fuel take-back PEIS, have included detailed nonproliferation analysis, even making non-proliferation a primary decision criterion.[5] Cost analysis has been included as a decision factor in some EIS's as well.[6] Indeed, even the draft plutonium disposition DPEIS explicitly cites "non-proliferation," "security," and "cost-effectiveness" as among the screening criteria used in the disposition

18/08.00.00 cont.

[3] Letter from Nuclear Control Institute, Greenpeace International, Nuclear Waste Citizens Coalition, Physicians for Social Responsibility, Institute for Science and International Security, and Nuclear Information Resource Service, to Energy Secretary Hazel O'Leary, April 29, 1996.

[4] Letter from Greg Rudy, Office of Fissile Materials Disposition, to Nuclear Control Institute, Nuclear Waste Citizens Coalition, Nuclear Information Resource Service, Greenpeace International, Institute for Science & International Security, and Physicians for Social Responsibility, May 6, 1996.

[5] Final Environmental Impact Statement: Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel, DOE/EIS-0218F, February 1996, Summary, pp. 51-59 (non-proliferation impacts of alternatives analyzed and compared); Draft F-Canyon Plutonium Solutions Environmental Impact Statement, DOE/EIS-0219D, August 1994, p. 2-13 ("security and nonproliferation" decision criterion "relates to how well each alternative supports national security objectives and nonproliferation"); Draft Environmental Impact Statement: Interim Management of Nuclear Materials, DOE/EIS-0220D, March 1995, p. 2-46 (decision criterion language identical to F-Canyon draft EIS); Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling, DOE/EIS-0161, Volume I, October 1995, p. S-8 (commercial irradiation services alternative ruled out of draft PEIS based on "nonproliferation concerns"; later incorporated into final PEIS based in part on "further consideration of nonproliferation issues"); Disposition of Surplus Highly Enriched Uranium Draft Environmental Impact Statement, DOE/EIS-0240-DS, October 1995, Summary, p. S-7 ("criteria against which to judge potential alternatives" based on President Clinton's 1993 nonproliferation policy and 1994 NAS report on plutonium disposition; "[t]hese criteria included [inter alia] nonproliferation; security ...".

[6] Spent Fuel Take-Back EIS, op. cit, pp. 62-63 (costs of alternatives analyzed and compared); Savannah River Site Waste Management: Draft Environmental Impact Statement, DOE/EIS-0217D, Volume I, January 1995, p. 2-78 ("A technology had to meet the following criteria to be deemed a potential technology ... (3) Its costs were comparable to other possible technologies"); Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs: Final Environmental Impact Statement, DOE/EIS-0203-F, Volume I, Summary, April 1995, p. 37 ("cost of implementation" a decision criterion, and comparative cost analysis integrated into PEIS); Draft Programmatic Environmental Impact Statement for Stockpile Stewardship and Management, DOE/EIS-0236, Volume I, February 1996, p. 3-1 ("planning assumptions and basis for analysis" in PEIS include "[m]aximize efficiency and minimize cost and waste consistent with programmatic needs"); Surplus HEU Disposition Draft EIS, op. cit, p. S-7 ("cost-effectiveness" among "criteria against which to judge potential alternatives").

M-281

values given in Table 4.4.3.3–4 of the PEIS represent the "Total Potential Fatalities" associated with the transportation of Pu oxide, uranium oxide, and MOX fuel, for the Reactor Alternative category. The quantities presented are a result of direct risk calculations which yield results in "numbers of human fatalities." In regard to accumulating the risks associated with a given transportation process, the maximum risk impacts from the transport of Pu oxide, uranium oxide, and MOX fuel under the Reactor Alternatives may be summed directly from Table 4.4.3.3–4. Section G.1.2.5 provides a description of the transportation effects on the global commons.

08 03 01 Comment Number 13

The Department of Energy acknowledges the commentor's support for the Vitrification Alternative. Decisions on disposition of weapons-usable fissile materials will be based upon environmental analyses, technical and economic studies, national policy considerations, and public input.

13 00 00 Comment Number 14

The safeguards and security of storage of the weapons-usable fissile materials will continue to follow existing applicable regulations and requirements. Furthermore, the facilities would be inspectable by IAEA, as appropriate. Transportation impacts are discussed in Section 4.4 and Appendix G of the PEIS. Armed nuclear material couriers carefully selected and highly trained to operate tractor-trailers and communication systems would be used. These couriers would also be authorized by the AEA to carry firearms and make arrests in the performance of their duties. No military personnel are anticipated to be used in DOE's management of weapons-usable fissile materials in the United States. However, the same level of security, or higher as deemed necessary, would be provided for sea shipments as that of U.S. over-land shipments. During transport on the ship and while in temporary storage at the seaports, appropriate security escort measures would be implemented. Any sea transport would also meet applicable IAEA requirements and the International Maritime Organization code.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 6 OF 47

PEIS process to rule out certain disposition alternatives.[7] Certainly the analyses used to support these cost and non-proliferation decisions should be incorporated into the PEIS itself. | 18/08.00.00 cont.

DOE's Office of Non-Proliferation and Arms Control, tasked with preparing the non-proliferation analyses, is developing a process whereby the public can comment on and participate in the development of that analysis.[8] The process will be modeled on the approach used in preparing the National Ignition Facility (NIF) non-proliferation analysis last year. While the opportunity for public input this approach will offer is beneficial and welcome, we also believe the nonproliferation analysis is an integral element of the screening criteria and decisions made in preparing the DPEIS, and should therefore be made a formal part of the PEIS. | 20/08.00.00

Moreover, we are not aware of any comparable public-input process for the economic analysis of disposition options being prepared by Oak Ridge National Laboratory. NEPA specifically requires that cost analyses, if prepared, be made a formal part of the EIS process. CEQ regulations, adopted by DOE for its implementation of NEPA,[9] provide that "[i]f a cost-benefit analysis relevant to the choice among environmentally different alternatives is being considered for the proposed action, it shall be incorporated by reference or appended to the statement as an aid in evaluating the environmental consequences. . . ."[10] [emphasis supplied] Courts have upheld this requirement, holding that "[t]he cost-benefit analysis of alternatives must be contained within the environmental impact statement standing alone, and not as complemented by the administrative record."[11] | 18/08.00.00 cont.

It is NCI's position, therefore, that the Secretary of Energy should extend the public comment period until 45 days after all relevant support documents, including the cost and non-proliferation analyses, are made publicly available. | 18/08.00.00 cont.

II. Non-Proliferation Issues

The absence of a non-proliferation analysis from the DPEIS is particularly egregious. First, the DPEIS itself states that "[t]he purpose of the proposed action is to implement the President's Nonproliferation and Export Control Policy in a safe, reliable, cost-effective, | 21/01.06.00

[7] DPEIS, Summary, p. S-5.

[8] Rudy letter, ibid.; Dave Airozo, "DOE Keeps Nonproliferation, Cost Analyses Out of Pu-Disposition PEIS," NuclearFuel, May 20, 1996, p. 12.

[9] 10 C.F.R. 1021.101; 10 C.F.R. 1021.103.

[10] 40 C.F.R. 1502.23 (emphasis added).

[11] National Wildlife Federation v. Marsh, 568 F.Supp. 985, 997 (D.D.C. 1983).

M-281

10 00 00 Comment Number 15

Air transport is not proposed as an option under the alternatives discussed within this PEIS. Transport of nuclear materials is limited to either land or sea. Furthermore, there is no intent or strategy for air transport to ultimately become a viable option under any of the alternatives presented in the document, even if the "Safety Series 6" regulations, referenced to on page 20 of 47 of your comments (page 564 of this CRD), are subsequently approved.

10 02 00 Comment Number 16

Type B packagings are currently certified safe by DOE and NRC for transporting radioactive materials. The comments were given consideration for the PEIS, but the analysis used is for currently certified packagings. If the safety certification for the packaging is withdrawn, then new analyses would be required through the DOT, NRC, and IAEA as appropriate.

10 00 00 Comment Number 17

The testing of shipping casks is beyond the scope of the PEIS. The risk analysis performed for the PEIS used data from currently approved DOT, NRC, and DOE-certified shipping casks to determine impacts. When a specific alternative for disposition of Pu has been selected, any additional data with respect to the risks associated with shipping casks containing Pu and/or MOX fuel would be incorporated into the analysis.

08 00 00 Comment Number 18

In the interest of openness and more informed decisionmaking, DOE released Technical Summary Reports to the public as soon as they became available. Cost data, along with technical and schedule data, was provided for public comment in Technical Summary Reports of both storage and disposition in the summer of 1996. Results of the nonproliferation analysis were made available to the public in the fall of 1996. Each of these analyses, which are separate from the NEPA process, will be integrated along with the environmental analysis and public input into DOE's decisionmaking process.

technically feasible, and timely manner."[12] Second, as mentioned above, among the screening criteria used to select and exclude alternatives from the DPEIS were President Clinton's 1993 non-proliferation policy, as well as such factors as "non-proliferation" and "security."[13] 21/01.06.00 cont.

NCI is also concerned about the failure to coordinate decisions regarding disposition of military plutonium with U.S. policy toward civilian plutonium. A study by the U.S. National Academy of Sciences (NAS) on the disposition of plutonium from dismantled nuclear weapons emphasized that "further steps should be taken to reduce the proliferation risks posed by all of the world's plutonium stocks, military and civilian, separated and unseparated...."[14] A similar point was made in a Rand Corporation report which said: "It is critical that countries pay attention to the proliferation threat from the civilian side if they want to maximize the non-proliferation value of dismantling U.S. nuclear weapons and those of the FSRs (former Soviet republics). If countries ignore the civilian threat, they can compound the problem by making wrong choices in how to deal with military materials."[15] 22/01.04.00

To date, the U.S. Government has not drawn both elements of the plutonium problem, military and civilian, into a unified, coherent national plutonium policy. The strong interconnection between military and civilian aspects of U.S. HEU policy has been missing in the case of plutonium. The principal reasons for this include the reluctance of the United States to challenge Western Europe, Japan and Russia on their civilian plutonium programs, as well as resistance from nuclear industry representatives and government policymakers who insist that plutonium is a resource to be utilized, not a waste to be disposed of. These are largely political judgements that give short shrift to or ignore altogether the underlying security risks of encouraging civilian use of separated plutonium.

If current plans proceed, the world will have far more separated plutonium in civilian than in military programs[16]—a trend that can only work against effective disposition of military plutonium by the present nuclear-weapon states if civilian stockpiles

[12] DPEIS, Summary, p. S-3.

[13] DPEIS, Summary, p. S-5.

[14] Committee on International Security and Arms Control, National Academy of Sciences, Management and Disposition of Excess Weapons Plutonium, 1994 [NAS 1994], p 34.

[15] Brian Chow and Kenneth Solomon, Limiting the Spread of Weapon-Usable Fissile Materials, Rand Corporation Report, November 1993, p. xii.

[16] David Albright, Frans Berkhout, and William Walker, World Inventory of Plutonium and Highly Enriched Uranium 1992, 1993. p. 200 & p. 206. Albright et al. calculate that 257 metric tons of plutonium were in military inventories at the end of 1990. By 2010, they project that up to 546 metric tons of plutonium will have been separated from civilian spent fuel, and that up to 266 metric tons will remain as surplus.

M-281

07 02 00 **Comment Number 19**

The costs associated with transporting the materials by sea, including related security, would be considered if the selected alternative(s) requires sea shipment. Cost data, along with technical and schedule data, was provided in a Technical Summary Report for disposition in the summer of 1996.

08 00 00 **Comment Number 20**

As noted by the commentor, DOE has prepared a nonproliferation analysis for the decisionmaker so that an informed decision can be made. Decisions on storage and disposition of weapons-usable fissile materials will be based upon environmental analyses, technical and economic studies, national policy considerations and public input. The nonproliferation study is part of national policy considerations.

01 06 00 **Comment Number 21**

In addition to the environmental analysis of the storage and disposition alternatives identified in this PEIS, DOE conducted technical, schedule, cost and nonproliferation analyses to assure an adequate basis for a ROD. These analyses were published as separate documents and were made available to the public for review and comment.

The United States has placed some of its weapons-usable materials under IAEA safeguards and is continuing efforts to make more available to IAEA. DOE is also assisting Russia with efforts to build new storage facilities and to establish new control and accountability capabilities for existing storage facilities. Through these efforts, there is hope to encourage greater international commitment to IAEA inspections and, thereby, further ensure meeting nonproliferation goals.

01 04 00 **Comment Number 22**

European, Japanese, and Russian civilian nuclear policies are beyond the scope of this PEIS and DOE's Proposed Action; coordination of U.S. policy and related nonproliferation impacts concerning U.S. origin civilian and

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC, PAUL LEVENTHAL
PAGE 8 OF 47

of plutonium eclipse military stockpiles as projected. It is therefore imperative that U.S. warhead-plutonium disposal policy and non-proliferation objectives be closely coordinated. 22/01.04.00 cont.

The NAS study proposed three proliferation risk factors for use in comparing plutonium-disposition options: risk of theft; risk of reversal; and impact on arms reduction.[17] Judged by each of these criteria, the option of irradiating weapons plutonium in nuclear reactors (the MOX option) poses far greater proliferation risks than the option of vitrifying plutonium with highly radioactive waste (the VHLW option).

The MOX Option Poses a Greater Risk of Diversion and Theft 23/08.03.01

The MOX option presents a greater risk of diversion primarily because of the fuel-fabrication stage, a process that is difficult to safeguard effectively in view of plutonium's characteristic of sticking to the surfaces of processing equipment, and of the large, unavoidable uncertainties in the measurements of this "held-up" material. Fuel fabrication is susceptible to systematic diversion schemes by state operators of the plants, or by individual plant workers in collaboration with outside states or groups. This stage is avoided with the VHLW option, making it a proliferation risk unique to the MOX option. This issue is not considered in the DPEIS' analysis of MOX fuel fabrication.[18]

Recent experience suggests that the proliferation risk at this stage of disposition could be substantial. Difficulties at the Plutonium Fuel Processing Facility (PFPF) in Japan suggest that purportedly state-of-the-art MOX fabrication plants are difficult if not impossible to safeguard effectively. In May 1994, the Nuclear Control Institute disclosed that a major plutonium inventory discrepancy was been building up at the PFPF since the plant began operating in 1988.[19] The Japanese government and International Atomic Energy Agency (IAEA) claim that this plutonium, amounting to about 70 kilograms, or more than eight significant quantities (SQs), is not missing because it has been measured as being held up—that is, stuck to surfaces in the remote-handling equipment. Such measurements are taken by means of neutron coincidence counting and are subject to a wide range of uncertainty, perhaps as much as 30 percent in some instances.[20] To end the uncertainty, the IAEA recently requested that Japan cut open the glove boxes to remove and physically produce the held-up plutonium for the purpose of establishing the plant's inventory. This request was strongly resisted by the Japanese and will not be met promptly,

[17] NAS 1994, pp. 23-27.

[18] DPEIS, Section 4.3.5.1.

[19] "'Astounding' Discrepancy of 70 Kilograms of Plutonium Warrants Shutdown of Troubled Nuclear Fuel Plant in Japan," Nuclear Control Institute, May 9, 1994.

[20] Paul Leventhal, "IAEA Safeguards Shortcomings—A Critique," Nuclear Control Institute, September 12, 1994. For further discussion of the limitations of IAEA safeguards on plutonium, see Marvin Miller, "Are IAEA Safeguards on Plutonium Bulk-Handling Facilities Effective?," Nuclear Control Institute, August 1990.

M-281

surplus "military" (weapons-usable) Pu is considered in the nonproliferation analysis that will be part of the decisionmaking process. As an example of this consistency and coordination, DOE is not proposing reprocessing of spent fuel generated by the use of MOX fuel consistent with U.S. policy against reprocessing of commercially generated spent fuel.

08 03 01 Comment Number 23

The Department of Energy acknowledges the commentor's opposition to the Reactor Alternative using MOX fuel. Decisions on disposition will be made based upon environmental analyses, technical and economic studies, national policy considerations (including nonproliferation analyses), and public input. The nonproliferation analysis, *Draft Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Materials Storage and Plutonium Disposition Alternatives*, examines the potential diversion risk using the MOX fuel fabrication, safeguards, "hold-up" material, and accountability to the IAEA and international community, among other things. This nonproliferation analysis has been made available for public comment and will be considered in the decisionmaking process.

as the IAEA had originally asked.[21]

It will reportedly cost more than $100 million to clean out all the held-up plutonium and rebuild the PFPF, and even then PNC offers no guarantee that all the plutonium can ever be recovered or accounted for. As of October 1995, the clean-out was not scheduled to be completed until the end of the year,[22] and it is not clear that the work has been completed even now. MOX fabrication plants in Europe, which might be used to produce warhead-plutonium MOX fuel,[23] have not made sufficient disclosure of the design and operating history of their material control and accounting systems to permit any conclusion about the effectiveness of safeguards at these facilities. Because safeguards at these facilities are fully implemented by EURATOM, neither the United States nor the IAEA is in a position to verify independently material balances.

This controversy over the plutonium hold-up problem at MOX fuel fabrication plants holds valuable lessons for the warhead-plutonium disposition process. MOX disposal schemes have unacceptable uncertainties and risks built into them that will make it impossible to determine whether all warhead plutonium has been accounted for.

Such uncertainty could severely limit the trust nations could place in an international nuclear arms-reductions and non-proliferation regime predicated upon recycling warhead plutonium as fuel for reactors. Thus, the existing uncertainty over effectiveness of safeguards at MOX fabrication plants undercuts a primary goal of the disposition process, " . . . to provide visible evidence of irreversible disarmament."[24] 23/08.03.01 cont.

There are also risks of theft with the MOX option that arise during transportation and storage of plutonium and MOX fuel, which are discussed below (see "Transportation Issues").

In a vitrification disposition scheme, separated plutonium is vulnerable to diversion only prior to its placement in the melter. After that, it is mixed with molten glass and, in most proposals, either mixed with or emplaced in highly radioactive fission products, making it inaccessible for all practical purposes. Safeguards efforts for vitrification must concentrate on preparation of plutonium for the melter (e.g., conversion from metallic to oxide form). At least one vitrification technology, the GMODS system under development 24/05.01.08

[21] Mark Hibbs, "IAEA Gives Japan Till 1995 to Account for Holdup Inventory at PFPF Plant," NuclearFuel, October 10, 1994, pp. 12-13.

[22] Mark Hibbs, "Rebuild at PNC's PFPF Plant Will Cost Japan $100-million," NuclearFuel, October 9, 1995, pp. 11-12; "Pu Hold-Up at PFPF Still Controversial," Nuke Info Tokyo, November/December 1995, p. 3.

[23] DPEIS, Section 2.4.5.1, p. 2-119.

[24] DPEIS, Summary, p. S-4.

M-281

05 01 08 Comment Number 24

The Glass Material Oxidation/Dissolution System Alternative was eliminated from further consideration upon determining that the research and development required precluded it from being used for disposition within a decade from the ROD. Should this alternative become technologically viable, it may be considered by DOE in subsequent tiered NEPA documents. Other technologically viable vitrification alternatives and vitrification variants are considered and analyzed in this PEIS.

at Oak Ridge National Laboratory, is intended to allow plutonium to be added in unaltered metallic form, avoiding this stage entirely and eliminating this diversion vulnerability.[25] 24/05.01.08 cont.

One promising vitrification option that should be assessed in detail in the DPEIS, but is not,[26] is now being developed. In January, scientists at the Savannah River Site in South Carolina successfully demonstrated the "can-in-a-canister" approach, which mixes weapons plutonium and molten glass in small metal cans. After cooling, these cans are to be placed in larger steel canisters, which would then be filled with a mixture of molten glass and highly radioactive waste, thus immobilizing the plutonium and meeting the NAS' spent fuel standard for final disposal. The operation would take place at the Defense Waste Processing Facility at Savannah River which recently began filling these larger canisters to dispose of thousands of gallons of high-level waste remaining from plutonium production during the Cold War. 5/01.02.00 cont.

Both Westinghouse, the contractor operating the Savannah River Site, and the DOE Office of Fissile Material Disposition are very encouraged by the promising results thus far. According to Nicholas Kuehn, coordinator of the can-in-a-canister project at Savannah River, a "cold test" in January to demonstrate vitrification in cans with non-radioactive material, "exceeded our best expectation." As a result, Kuehn stated, can-in-a-canister is "certainly at the top of the list for immobilization options." A "hot test," in which actual plutonium will be vitrified in a can, will take place at Lawrence Livermore Laboratory later this year.[27] 25/05.00.06

The safeguards advantages of immobilization are noted in the NAS study. It concluded that fabrication of HLW waste logs would

> . . . be easier to safeguard than fabrication of MOX fuel bundles. Monitors would have to confirm only the single step of mixing the plutonium with the HLW. Once that step had taken place, the plutonium would be in an intensely radioactive mix and very difficult to divert. There would be no capability within the vitrification facility for re-separating the plutonium from the HLW.

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[25] C.W. Forsberg et al., Oak Ridge National Laboratory, "Direct Conversion of Spent Fuel to High-Level-Waste (HLW) Glass," Paper Presented to American Nuclear Society Conference, Salt Lake City, Utah, September 28, 1994.

[26] The DPEIS does not assess the "can-in-a-canister" approach in detail because it only analyzes the environmental consequences of a new, or "greenfield," vitrification plant. DPEIS, Section 4.3.4.1. Such an approach is inappropriate, because it skews the decision process toward MOX options by overestimating the environmental impacts of vitrification options that would use existing facilities (such as "can-in-a-canister" at DWPF) relative to MOX options. This point is elaborated in the environmental safety and health section of these comments.

[27] George Lobsenz, "Can In a Canister? DOE Considers Novel Plutonium Disposition Process," Energy Daily, May 31, 1996, p. 1.

05 00 06 **Comment Number 25**

Comment noted.

MOX fabrication, by contrast, requires many steps involving large-scale bulk handling of plutonium, with inherent accounting uncertainties, and at each step of the process the plutonium remains in a form from which it could be readily reseparated.[28]

The MOX Option Poses a Greater Risk of Reversal

The proliferation resistance of the final waste forms largely determines the potential reversibility of plutonium disposition. Appendix H of the DPEIS, "High-Level Waste Forms Comparative Analysis," fails to examine these issues. A detailed comparative analysis of plutonium retrievability from spent MOX fuel and immobilized glass and ceramic waste forms must be included along with the factors already addressed, such as regulatory issues, criticality, thermal load, radiation, and releases. 26/06.01.08

Reversibility is a function of three factors. The first is the amount of residual plutonium remaining in the final waste forms. The MOX option would leave modestly less plutonium in final waste than the VHLW option. However, it is misleading to speak of MOX "burning" of weapons plutonium as if all or even most of the plutonium is consumed during irradiation. In fact, irradiated weapons-plutonium MOX fuel would contain only about 30 percent less total plutonium than fresh MOX.[29]

The second factor is retrievability of the residual plutonium. Separation of plutonium from fresh MOX fuel is a straightforward chemical process. Reprocessing irradiated MOX fuel by means of PUREX employs proven technology that could recover substantial amounts of plutonium. Chemical separation of plutonium from VHLW is a similar chemical processes, roughly comparable in difficulty.[30]

The third factor is the isotopic composition of the residual plutonium in the final waste forms. Plutonium disposed of in VHLW remains weapons-grade, except for normal radioactive decay. Weapons plutonium in irradiated MOX fuel contains a considerably smaller proportion of fissile isotopes after irradiation than before. This factor, however, is not nearly as important from a non-proliferation perspective as some have argued. Many MOX proponents emphasize the degree to which the isotopics of the weapons plutonium would be altered by irradiation in a particular reactor technology—that is, the degree to

[28] NAS 1994, p. 192.

[29] Panel on Reactor-Related Options for the Disposition of Excess Weapons Plutonium, Committee on International Security and Arms Control, National Academy of Sciences, Management and Disposition of Excess Weapons Plutonium: Reactor-Related Options, 1995 [NAS 1995], Table 6-5, p. 270, indicates that a fresh weapons-plutonium MOX fuel element would contain 25 kilograms of plutonium. The same element, after irradiation to a burn-up of 40 megawatt-days per kilogram heavy metal, would contain 18 kilograms of plutonium.

[30] NAS 1995, p. 243.

M-281

06 01 08 Comment Number 26

Proliferation resistance is the primary objective of the Fissile Materials Disposition Program. To ensure each disposition alternative provides sufficient proliferation resistance, an independent team of safeguards and security experts is assessing the proliferation vulnerability of the various disposition alternatives. The purpose of this assessment is to identify potential weaknesses in the proliferation resistance and, thus, the effectiveness of the disposition alternatives to threats of material theft and/or retrieval and reuse.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 12 OF 47

which the Pu-239 proportion can be reduced—as if this factor should be decisive in choosing among disposition technologies.

This is an inappropriate criterion by which to assess proliferation risks because it perpetuates a dangerous myth that reactor-grade plutonium cannot be used to make workable weapons. The ability to construct a weapon from reactor-grade plutonium was demonstrated decades ago. It is dangerous even to consider it an open question. Hans Blix, director-general of the IAEA, informed our Institute that there is "no debate" on this point in the Safeguards Department of the IAEA, and that the agency considers virtually all isotopes of plutonium, including high burn-up reactor-grade plutonium, to be usable in nuclear weapons.[31] In June 1994, U.S. Energy Secretary Hazel O'Leary declassified further details of a 1962 test of a nuclear device using reactor-grade plutonium, which successfully produced a nuclear yield.[32] 7/01.06.00 cont.

In a future breakout scenario, the United States (or Russia) could presumably draw on its nuclear test data and predictive capabilities to reconfigure weapons designs and reconstitute a large arsenal, even from plutonium isotopically degraded to reactor-grade by irradiation in MOX. Also, development of laser isotope separation, such as AVLIS, is likely eventually to permit the "mining" of the Pu-239 isotope from reactor-grade plutonium. If isotopic degradation were determined to have some utility from a non-proliferation perspective (for example, to establish parity with non-nuclear-weapon states storing high burn-up plutonium in the form of spent fuel), weapons plutonium could be mixed with reactor-grade plutonium, possibly from surplus stockpiles of separated civil plutonium in Great Britain or Russia, to dilute it isotopically prior to vitrification with HLW. 27/01.06.00

Our main point is, however, that isotopic degradation does not pose a substantial barrier to re-militarization of warhead plutonium, and therefore does not constitute a compelling argument in favor of the MOX option. It is important to note that the 1995 NAS study agreed with this conclusion. In its comparison of the MOX and VHLW options it found that "[t]he plutonium in the spent fuel assembly would be of lower isotopic quality for weapons purposes than the still weapons-grade plutonium in the glass log, but *since nuclear weapons could be made even with the spent fuel plutonium this difference is not* 28/08.03.00

[31] Letter from Hans Blix, Director-General of the IAEA, to Paul Leventhal, NCI, November 1, 1990; "Blix Says IAEA Does Not Dispute Utility of Reactor- Grade Pu for Weapons," Nuclear Fuel, November 12, 1990, p. 8. However, Blix made this statement only after the Nuclear Control Institute challenged assertions by IAEA officials earlier that year that reactor-grade plutonium was unsuitable for use in weapons.

[32] U.S. Department of Energy, Office of the Press Secretary, "Additional Information Concerning Nuclear Weapon Test of Reactor-Grade Plutonium," DOE Fact Sheet released as part of the Openness Initiative, June 27, 1994. The fact that the test occurred and produced a nuclear yield was declassified in 1977. Robert Gillette, "Impure Plutonium Used in '62 A-Test," Los Angeles Times, September 16, 1977, part 1, p. 3.

M-281

01 06 00 **Comment Number 27**

Comment noted.

08 03 00 **Comment Number 28**

The proliferation resistance of each alternative is the subject of a separate study conducted by DOE's Office of Non-Proliferation and National Security. The results of this study will, along with the PEIS and other information, be presented to the decisionmaker so that good sustainable decisions can be made.

decisive."[33] [emphasis supplied] This point should be explicitly made explicitly in the final PEIS and record of decision. 28/08.03.00 cont.

The MOX Option Poses a Threat to Arms Control and Non-Proliferation Efforts

In its non-proliferation policy statement, the Clinton administration declared that "the United States does not encourage the civil use of plutonium and, accordingly, does not itself engage in plutonium reprocessing for either nuclear power or nuclear explosive purposes."[34] Though it does not necessarily involve further reprocessing, the MOX option would clearly encourage the civil use of plutonium, which in a number of countries includes plans for reprocessing irradiated MOX fuel. The U.S. Government (or its duly authorized agents) would be engaging in MOX activities for the first time on a commercial scale, legitimizing the use of MOX in civil nuclear power programs. 29/06.01.08

Such a sea change in U.S. policy would confuse and complicate U.S. non-proliferation diplomacy. It would send the wrong signal to Western Europe, Japan, and other non-nuclear-weapon state members of the Non-Proliferation Treaty (NPT). The NAS study conceptualized this issue as the "Fuel Cycle Policy Signal":

> [P]olicymakers will have to take into account the fact that choosing to use weapons plutonium in reactors would be perceived by some as representing generalized U.S. approval of separated plutonium fuel cycles, thereby compromising the ability of the U.S. government to oppose such fuel cycles elsewhere. Conversely, choosing to dispose of weapons plutonium without extracting any energy from it could be interpreted as reflecting a generalized U.S. government opposition to plutonium recycle. Either choice could have an impact on fuel cycle debates now underway in Japan, Europe, and Russia.[35]

The DPEIS implicitly acknowledges the importance of the fuel cycle policy signal when it posits that one of the goals of the disposition process is "to strengthen national and international arms control efforts by providing a storage and disposition model for the international community."[36] But the DPEIS does not cite the NAS finding or explicitly consider the fuel cycle policy signal that the MOX option would send relative to alternative immobilization options. 30/01.06.00

[33] NAS 1995, p. 413.

[34] White House Fact Sheet, "Nonproliferation and Export Control Policy," September 27, 1993, p. 2.

[35] NAS 1994, p. 149.

[36] DPEIS, Summary, p. S-4.

M-281

06 01 08 Comment Number 29

Converting surplus MOX fuel is not the end state. The end state is to use the MOX fuel in a reactor, so that after irradiation, it meets the Spent Fuel Standard for proliferation resistance. While the Pu is in the MOX fuel form, it would be subject to high standards of safeguards and security.

While the PEIS discusses the generation of spent fuel as an indirect result of potential disposition actions, any subsequent reprocessing and extraction of Pu from that spent fuel is not being proposed by DOE and is contrary to the fundamental nonproliferation purpose of the disposition effort. The PEIS evaluates disposition of surplus weapons Pu through use in MOX fuel, but does not further propose or evaluate reprocessing of the spent fuel and does not suggest reprocessing for the management or disposition of the spent fuel.

01 06 00 Comment Number 30

The U.S. fuel cycle policy is unchanged. The Pu would be consumed in a reactor using a once-through fuel cycle, then disposed of as spent nuclear fuel. No reprocessing would be involved in surplus Pu disposition, consistent with the President's Nonproliferation Policy. The Nonproliferation Policy impact analysis for the alternatives described in the PEIS is presented in a separate document made available for public review in the October 1996.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 14 OF 47

The MOX option sends the wrong fuel cycle policy signal in three ways. First, the MOX option effectively declares that plutonium has an asset value, and that the energy contained within it should be viewed as a "national asset" (as the U.S. DOE puts it)[37] or even "national heritage" (as the Russians put it).[38]

Second, the MOX option suggests that a plutonium fuel cycle can be effectively safeguarded, and the use of MOX for weapons plutonium disposition would surely be cited by plutonium advocates as a government "seal of approval" on the process.

Third, the MOX option would be portrayed as giving credibility to the claim that plutonium recycle in light-water reactors (LWRs) is essential to nuclear waste management. Despite the fact that both unaltered spent fuel and high-level waste derived from reprocessing produce comparable amounts of penetrating radiation and short-term thermal output,[39] reprocessing advocates have seized upon the separation and re-use of plutonium as the sine qua non of effective waste management.

Reprocessing proponents would seize upon the use of MOX in the disposition process as a U.S. government policy statement that plutonium can be effectively disposed of by means of fissioning it in MOX-fueled reactors. The MOX fuel used to irradiate weapons plutonium could be reprocessed, and the plutonium industry, particularly in Japan and Germany, would continue to press for this option as a means to "eliminate" completely plutonium over hundreds of years. If total plutonium elimination becomes the goal of a plutonium-recycling program, fast reactors—with all their poor economics, safety hazards, and proliferation risks— would become inevitable, because for technical reasons plutonium cannot be recycled more than two or three times in thermal reactors.[40] Even then the goal of total elimination would be futile, because most fast reactors are breeders that produce more plutonium than they consume. The U.S. warhead-plutonium disposition program should not in any way lend credence to such misguided efforts. 22/01.04.00 cont.

Thus, a general category of danger from the MOX option would be the perpetuation of overseas plutonium and breeder reactor programs. Russia's current position is to keep weapons plutonium in long-term storage pending its eventual use as fuel for LWRs and fast 31/01.06.00

[37] "Report Calls Plutonium a 'National Asset,'" Denver Post, July 29, 1993.

[38] Frank von Hippel, Federation of American Scientists' Fund, Cooperative Research Project on Arms Reduction: Sixth Annual Report, August 22, 1993, p. 3.

[39] U.S. Office of Technology Assessment, Managing the Nation's Commercial High-Level Radioactive Waste, March 1985, pp. 68-75.

[40] Report by the Working Party on Physics of Plutonium Recycling, NEA Nuclear Science Committee, Physics of Plutonium Recycling, Volume I: Issues and Perspectives, OECD Nuclear Energy Agency, 1995, pp. 115-116.

M-281

01 06 00 Comment Number 31

The U.S. fuel cycle policy is unchanged. The Pu would be consumed in a reactor using a once-through fuel cycle, then disposed of as spent nuclear fuel. No reprocessing would be involved in surplus Pu disposition, consistent with the President's Nonproliferation Policy. The Nonproliferation Policy impact analysis for the alternatives described in the PEIS is presented in a separate document made available for public review in the fall of 1996. DOE feels that this will not provide any signal or support foreign reprocessing.

breeder reactors.[41] The U.S. would have little credible basis upon which to oppose Russia's plutonium fuel cycle plans if the U.S. were to select the MOX option and would also provide tacit support to European and Japanese plutonium programs. 31/01.06.00 cont.

A further danger is that the MOX option would undercut U.S. non-proliferation diplomacy directed at so-called "rogue states." With the U.S. actively pursuing the MOX option, it becomes far more difficult to deny nations of proliferation concern their "right" to civil use of plutonium as members of the NPT. North Korea claimed, albeit with little credibility, that its reprocessing plant at Yongbyon was intended to separate plutonium for use in MOX fuel for civilian nuclear power reactors. Though it agreed in October 1994 to abandon plans for indigenous reprocessing facilities, the ultimate disposition of plutonium contained in the remaining MAGNOX spent fuel and in future LWR spent fuel has yet to be determined. Overseas reprocessing has not been ruled out; nor has recycling of plutonium as MOX fuel in North Korea been specifically precluded. 32/01.04.00

At the third NPT PrepComm meeting, Iran threatened to withdraw from the NPT because, it charged, Iran and other NPT non-nuclear-weapon states were being denied nuclear technology that was their due under the terms of Article IV. India and Pakistan, though not NPT members, pursue plutonium programs that they justify as a legitimate part of their civil nuclear programs, and China anticipates reprocessing the spent fuel from its nuclear-power plants.

The only credible way to oppose the separation and use of plutonium as well as acquisition and use of HEU in nations of proliferation concern is to oppose it comprehensively—that is, to oppose such use in any nation for any purpose. This approach is effectively precluded if the U.S. insists upon retaining the right to use MOX fuel in civilian reactors, even if only for the purpose of weapons plutonium disposition. 33/08.03.01

Pyroprocessing Immobilization Alternative Must Be Rejected[42]

The DPEIS (Section 2.4.3.3) posits "electrometallurgical treatment" as one of the immobilization options. In this option, pyroprocessing technology developed by Argonne National Laboratory as part of the Integral Fast Reactor (IFR) Program, now cancelled, would be used to produce a zeolite waste form. Cesium-137 or high-level waste would be incorporated into the waste form to create a radiation barrier.[43]

While we strongly favor the immobilization options generally over the reactor 34/01.04.00

[41] Mark Hibbs, "G-7 Concessions Mark Triumph for Minatom's Strategic Aims," Nucleonics Week, April 25, 1996, p. 9.

[42] This section was prepared by Daniel Horner, deputy director of the Nuclear Control Institute.

[43] DPEIS, p. 2-114.

01 04 00 Comment Number 32

Comment noted.

08 03 01 Comment Number 33

The Department of Energy acknowledges the commentor's opposition to the Reactor Alternative using MOX fuel. Decisions on disposition of weapons-usable fissile materials will be made based upon environmental analyses, technical and economic studies, national policy considerations, and public input.

01 04 00 Comment Number 34

The Department of Energy acknowledges the commentor's opposition to the Electrometallurgical Treatment Alternative. Information and assessments on electrometallurgical treatment will be taken into account in the decisionmaking process. Separate technical, schedule, and costs analyses on the disposition options, including electrometallurgical treatment, were issued by DOE beginning in late July 1996; the nonproliferation analysis of the disposition options, including electrometallurgical treatment, was issued for public comment in October 1996. The Electrometallurgical Treatment Alternative is analyzed in the PEIS because it is a "reasonable" alternative, and as such, must be analyzed under NEPA. Section 2.4.4.3 of the PEIS has been revised to note the NAS concerns regarding the use of electrometallurgical treatment for Pu disposition.

options, we do not support all the immobilization options. We strongly oppose the electrometallurgical treatment alternative ("pyroprocessing"). A recent NAS study noted the proliferation risks of proceeding with pyroprocessing: 34/01.04.00 cont.

> Developing technology that effectively extracts the plutonium from mixtures could facilitate decommissioning of former weapons manufacturing facilities and mitigate some of the problems found at these facilities, such as corroding fuel. However, such efficient technology also raises concerns about proliferation; what the United States might use to assist in the cleanup of a contaminated facility such as Rocky Flats could be used by another country to obtain plutonium for a weapons program.[44]

We cannot understand why this option was even included among the alternatives. The 1995 NAS study summarized its views on pyroprocessing as follows: 34/01.04.00 cont.

> The pyroprocessing approach, which would use technology developed as part of the U.S. Integral Fast Reactor program, would require substantial additional engineering development and construction of major new facilities (including what would amount to a sizable LWR fuel reprocessing plant to provide feed material), and it would provide a waste form that has not been characterized at all for long-term disposition and would probably be unsuitable for emplacement in Yucca Mountain. All this strikes our panel as a prescription for long delays and big investments in pursuit of highly uncertain prospects for solving a problem for which satisfactory approaches -- the current-reactor/spent fuel and borosilicate-glass/vitrification options -- are much closer at hand.[45]

These problems were not even addressed, let alone rebutted, in the DPEIS.

This summary analysis alone indicates that pyroprocessing should have been ruled out on the grounds of timeliness, technical maturity, ES&H, policy (because, like options R10, R11, and R13, it involves reprocessing), and cost-effectiveness. Indeed, one wonders what the purpose of the screening criteria is if an option can fail to meet so many of them and still be included among the options considered in the DPEIS. 34/01.04.00 cont.

Among the other critiques of pyroprocessing was an internal DOE memo, which analyzes and rejects each of the rationales for continuation of the pyroprocessing program, concluding that "[t]he promise of simplicity and being inexpensive just does not seem to be

[44] Gregory R. Choppin, et al., An Evaluation of the Electrometallurgical Approach for Treatment of Excess Weapons Plutonium, National Research Council, 1996 [Choppin], p. 27.

[45] NAS 1995, p. 412. A more detailed analysis appears on pp. 219-221.

born [sic] out in practice."[46] As indicated in this memorandum, the recent report by the National Academy of Sciences did highlight the serious potential problems from plutonium loading in the pyroprocessing waste form:

> Criticality concern related to the long-term post-closure repository performance of the GBZ [glass-bonded zeolite] waste form cannot be addressed readily, because the exact composition of the waste forms is still undetermined. The resulting technical concerns are exacerbated by the expected concentration of plutonium at the front of the loading columns during processing.[47]

The report also raised important questions about the waste forms with regard to radioactive decay effects, chemical stability, thermal stability, and long-term waste-from performance.[48]

With regard to the assessment of pyroprocessing in the 1994 and 1995 NAS plutonium-disposition studies, the report said:

> Given the great concern about the fate of weapons plutonium, the CISAC reports recommended against approaches that would require significantly more time to develop, or would entail significantly greater uncertainty, than alternatives that could be available in a shorter time with less uncertainty. That conclusion was based on an earlier version of the electrometalurgical approach. Although this committee has not examined costs, the committee believes that the uncertainty and timeliness for the present proposed electrometallurgical technique would not alter the conclusion of the earlier report.[49]

DOE clearly was aware of this recent study as it prepared the DPEIS, as the study is cited on page 2-114 of Volume I. But the footnote is rather remarkable. It says, "The National Academy of Sciences recently completed an evaluation and draft report on this subject. The results of this evaluation will be considered in the preparation of the Final Storage and Disposition PEIS." The study was completed and DOE was aware of it, but obviously chose not to incorporate into the analyses it conducted in preparing the DPEIS. It is difficult to avoid the conclusion that DOE ignored this study (as well as the other

34/01.04.00 cont.

[46] "Comments on the Electrometallurgical Process," attachment to letter to Bill Danker, MD-1, from Leonard Gray, Task Leader, Fissile Materials Immobilization Task, Fissile Materials Disposition Project, 30 August 1995.

[47] Choppin, p. 24.

[48] Choppin, pp. 6 and 22-26.

[49] Choppin, pp. 27-28.

critiques cited above) so that it could include pyroprocessing as one the disposition options, notwithstanding the overwhelmingly negative assessments of it by independent experts. | 34/01.04.00 cont.

IV. Transportation Issues[50]

Transport Security Issues

This section addresses security and safety concerns related to the transport of plutonium and mixed-oxide fuels, as described in the DPEIS's evaluation of plutonium disposition options.

First, it must be noted that the selection of any reactor disposition option will increase transportation risks by adding two extra steps to the disposition process. Weapons-grade plutonium will have to be transported from a plutonium conversion facility to a MOX fuel fabrication plant. Mixed-oxide (MOX) reactor fuel would be sent from the fuel fabrication plant to a reactor site or sites. The DPEIS recognizes the security risks involved and states an SST will be used "to minimize potential for diversion."[51] The NAS study pointed out the single-site location of weapon-plutonium vitrification as a factor that would reduce the risk of theft relative to MOX options.[52]

Transport risks would increase even more if a decision were made to fabricate MOX fuel in Europe, pending construction of a domestic fuel fabrication plant. This scenario would require trans-Atlantic sea shipments of weapons-grade plutonium and unirradiated MOX reactor fuel. Although the DPEIS assumes construction of a U.S. MOX plant within six years, regulatory obstacles and public resistance could delay construction beyond the time a MOX plant would be needed. In that case, more frequent shipments to and from Europe would be necessary. Furthermore, if MOX were to be used to fuel a CANDU reactor, and were to come to a U.S. military or other port of entry, an additional transportation step would be required to send fresh MOX fuel to Canada. This last variation is not addressed in the DPEIS. | 35/10.00.00

Transportation risks could be minimized, however, by opting for direct disposal of surplus plutonium as waste. Any of the immobilization options would require less transportation of weapons-usable materials and thereby reduce safety and security risks. If conversion and vitrification were done at the Pantex site, it would eliminate the need to transport plutonium from the storage facility to an immobilization plant. | 36/10.00.00

At issue are shipments of large quantities of weapons-usable materials. If fuel | 35/10.00.00 cont.

[50] This section was prepared by Sharon Tanner, vice president of the Nuclear Control Institute.

[51] DPEIS, p. 2-123.

[52] NAS 1995, p. 243.

M-281

10 00 00 Comment Number 35

The PEIS analysis assumes that transport of Pu by ship would be done by dedicated British Nuclear Fuel, Limited, or COGEMA ships from military seaports in the United States to seaports in Great Britain or France. The transport would meet applicable IAEA requirements and the IMO code. While in temporary storage at the seaports and during transport on the ship, appropriate escort security measures would be implemented.

Section G.1.2.5 provides a description of the transportation effects on the global commons and includes the results of an environmental assessment of the sea shipment of Pu, *Environmental Assessment of the Import of Russian Plutonium-238,* referenced in the PEIS as DOE 1993x. Technical and licensing issues related to the MOX fuel fabrication have been considered by DOE in the technical evaluations of the storage and disposition alternatives, which were issued in late July 1996. It is anticipated that MOX fuel fabricated in Europe would not be used in a reactor in Canada.

10 00 00 Comment Number 36

The PEIS transportation analysis includes the movement of material required for disposition at more than one location. If the common activity facilities (for example, pit disassembly facility) are located at the same site as the disposition activity facilities (for example, ceramic immobilization facility) there would be a reduction in the transportation risk. The current analysis is bounding for activities at multiple sites.

fabrication were done in the United States, the DPEIS estimates the fabrication plant would receive 20 shipments of plutonium annually and send 174 shipments of reactor fuel bundles to a reactor site or sites.[53] If a European fuel-fabrication facility were used, there would be two sea shipments to Europe each year of two to four tons of weapons-grade plutonium and four sea shipments annually to the United States of fresh MOX fuel.[54]

Use of an existing European fuel-fabrication facility is described as an interim, short-term option because construction of a U.S. plant is projected to take six years.[55] But during this time, there could be a dozen sea shipments of plutonium to Europe and twice that number of shipments of MOX fuel to the United States. The U.S. has advised Japan repeatedly that Japan must provide an armed escort for Japanese shipments of reactor-grade plutonium in oxide or mixed-oxide form from France to Japan.[56] There needs to be an explicit requirement for a comparable armed escort for U.S. sea shipments of weapons-grade plutonium and mixed-oxide reactor fuel fabricated from it. 35/10.00.00 cont.

The transport of many "significant quantities" of weapons-materials raises security concerns that are directly relevant to selection of a disposition option. With respect to plutonium, the DPEIS commits to the use of Safe Secure Transport vehicles [SST] in the United States. However, the DPEIS is not clear on the arrangements for domestic transport of unirradiated MOX fuel.

On this point, the text is inconsistent and contradictory. Table 4.4.2.2.-1 indicates MOX fuel will be transported by "truck," with no mention of an SST. Elsewhere, use of an SST, an SST "container," or a certified commercial truck carrier" is described.[57] The report notes that "standard commercial practice" will be followed,[58] even though there is no commercial MOX industry in the U.S. And there is no discussion of security arrangements with the government of Canada—which presumably has no SSTs—if CANDU reactors were used. These matters require clarification. 37/10.00.00

[53] DPEIS, p. 4-782.

[54] DPEIS, p. G3.

[55] DPEIS, p. 2-123.

[56] Letter from Fred McGoldrick, Director, Office of Nuclear Non-Proliferation and Export Policy, U.S. Department of State, October 25, 1993, to Tom Clements, Greenpeace International Plutonium Campaign.

[57] DPEIS, pp. 4-771-4772. "Pu and HEU would be transported in truckload shipments by safe secure trailer (SST). The other materials would be transported by commercial truck . . . " DPEIS, Appendix G, Intersite Transportation, p. G-1. "For the shipment of Pu oxide from lag storage to an overseas MOX fuel fabrication site and the return shipment of reactor fuel assemblies, (1) material must be transported by safe secure trailer (SST) to or from the selected U.S. port . . . " DPEIS, Appendix G, p. G-3.

[58] DPEIS, p. 4-782.

M-281

10 00 00 Comment Number 37

Transportation from the MOX fuel fabrication site to a reactor site would be in accordance with DOE's SST system, to ensure the safe transport of this material. If the CANDU Reactor Alternative were selected at the ROD, transportation requirements would be coordinated with Canadian authorities for the safe secure transport of the MOX fuel. Sections 4.4.2 and G.1.1 of the Final PEIS have been clarified to correct the confusion for the utilization of SST, for fresh MOX fuel shipment.

The PEIS analysis assumes that transport of Pu by ship would be done by dedicated British Nuclear Fuel, Limited, or COGEMA ships from military seaports in the United States to seaports in Great Britain or France. The transport would meet applicable IAEA requirements and the IMO code. While in temporary storage at the seaports during transport on the ship, appropriate escort security measures would be implemented.

The DPEIS does not discuss the security arrangements for sea shipments of plutonium or MOX reactor fuel. These arrangements are likely included in the classified appendix on transportation.[39] However, some aspects of these arrangements should be made a part of the public record and subject to independent evaluation. 37/10.00.00 cont.

There is ample precedent for public debate on these issues. The physical protection arrangements for sea shipment of plutonium have been discussed publicly at least since the 1984 sea shipment of 184 kilograms of plutonium from France to Japan. The need for a military escort was debated in the American and Japanese press prior to the *Akatsuki-maru* shipment in 1993. The Department of State has stated on more than one occasion that the U.S. would require an armed escort vessel for any future sea shipment of mixed-oxide fuel.[40]

The DPEIS needs to state publicly what level of security will be required for shipments of plutonium and MOX. This can be done without providing explicit details regarding armament, routing and scheduling that might prove useful to a potential adversary. Anything less than an armed military escort should be unacceptable, given U.S. insistence on an armed escort for any shipment of MOX fuel containing U.S.-origin reactor-grade plutonium from France to Japan. The United States should provide no less for shipments of U.S. weapons-grade plutonium. 14/13.00.00 cont.

Cost comparisons for the different plutonium disposition options should also reflect the cost of security requirements for sea shipments. U.S. naval vessels have been used in the past to protect plutonium shipments between France and Japan. This expense should be reflected in any cost evaluations of the different disposition alternatives. 19/07.02.00 cont.

The DPEIS rules out air transport of any nuclear materials.[41] This reflects the U.S. Government's correct rejection of the arguments made at the IAEA that MOX fuel is a "low-dispersible" material and therefore can be flown in a Type B cask. New Safety Series 6 regulations are expected to permit air shipment of MOX in a Type B cask, but the IAEA Board of Governors has not yet approved the new code. NCI has urged the Board to reject the new standards.[42] 15/10.00.00 cont.

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[39] DPEIS, p. 4-783.

[40] "Kansai Electric's Shipment Will Require Armed Escort Ship," July 23, 1993, press release from Plutonium Action Network - Kyoto. Also, letter from Fred McGoldrick, State Department, to Tom Clements, Greenpeace International, October 25, 1993.

[41] DPEIS, p. 4-772.

[42] Letter to Dr. Hans Blix, Director General, International Atomic Energy Agency, from Paul Leventhal, President, and Dr. Edwin Lyman, Scientific Director, Nuclear Control Institute, February 26, 1996; IAEA response from Morris Rosen, Deputy Director General, March 25, 1996. NCI response to Mr. Rosen is in preparation. NCI press release, "NCI Denounces as a Fraud a New IAEA Safety Standard for Air Shipments

Air transport was the preferred option in the late 1980s for the return of plutonium from France to Japan. Air transport reduces many of the security concerns associated with sea shipment. However, there is no crashworthy cask available for air shipment of plutonium or MOX fuels. Air shipment was rejected in favor of sea shipment after the Nuclear Control Institute raised Congressional concerns over the environmental consequences of an air crash involving plutonium shipment casks that could not withstand a high velocity crash.[63] No commercial cask is licensed for plutonium air transport in the United States.

Transport Safety Issues

Appendix G compares transportation impacts for the different disposition alternatives. The analysis understates the environmental hazards of transporting radioactive material by embracing the Type B transport standards and assigning a low probability to an accident that could result in a breach of the cask. The appendix disregards recent expert reports that challenge the adequacy of the Type B standards,[64] as well as ongoing initiatives within the IAEA and the International Maritime Organization (IMO) to re-evaluate these standards in the context of historical data about accident conditions. The DPEIS' analysis is cursory and outdated, and must be revised to take into account the most recent studies and the ongoing IAEA and IMO re-evaluations of these casks. 16/10.02.00 cont.

The DPEIS suffers from the following defects:

- The DPEIS finds no "significant accident risks apart from the remote possibility of a major fire" involved in the handling and short-term storage of plutonium and MOX containers in port facilities. There is no further analysis of the risk of a major fire.[65] 38/10.02.00

- The DPEIS dismisses the risk of a radioactive release were a container to be dropped during loading or offloading. The "yielding nature" of the port surface, it is claimed, would reduce the likelihood of a breach of the container. 39/10.02.00

of Plutonium," March 1, 1996.

[63] The Markowski Amendment, Section 5061 of the Omnibus Budget Reconciliation Act of 1987 was enacted following release of NCI's Special Report, "Air Transport of Plutonium Obtained by the Japanese from Nuclear Fuel Controlled by the United States," March 3, 1987.

[64] Illinois Institute of Technology Research Institute (IITRI), "Definition of Bounding Physical Tests Representative of Transport Accidents—Air and Marine," IITRI KO6019, November 1983; ECO Engineering, Inc., Annapolis, MD., "A Review of the Proposed Marine Transportation of Reprocessed Plutonium from Europe to Japan, March 1992: Edwin S. Lyman, Princeton University School of Engineering/Applied Sciences, "Safety Issues in the Sea Transport of Vitrified High-Level Radioactive Wastes to Japan," December 1994.

[65] DPEIS, p. G-3.

10 02 00 Comment Number 38

Section G.1.2 of the PEIS describes port transit risk, which includes thermal (fire) conditions. Conservative port handling impacts based on the methodology described in Appendix G are presented in Table G.1–1. Pu and MOX fuel require the use of highly sophisticated Type B packagings that are specifically designed to prevent the release of contents under all credible transportation accident conditions (such as during handling in port). Appendix G has been modified to provide clarification for sea shipments and handling of Pu and MOX containers in port facilities.

10 02 00 Comment Number 39

Safety is in the packaging, which is specifically designed to prevent a release of radioactive material under all credible accident circumstances such as loading and unloading operations. Packaging is designed to withstand a drop test onto a flat, essentially unyielding surface. A yielding port surface could further reduce potential risk. The sequence of tests for ensuring the reliability of the 6M, Type B packaging is described in Section G.5 of the PEIS.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 22 OF 47

• The DPEIS reaffirms the ability of a type B package to survive a major shipboard fire. It repeats familiar arguments: the likelihood that a shipboard fire will occur in the same location as the cargo is relatively small; the duration of a shipboard fire does not necessarily mean any single package will be threatened; unless a package is "engulfed" by a fire, it does not matter whether the fire reaches sustained temperatures above the regulatory fire temperature of 800 degrees C., nor is the fire's duration likely to be a factor in maintaining the container's integrity.[66] 40/10.00.00

At the same time, the appendix concedes that "[H]owever unlikely, there is always a potential for maritime accidents during the ocean shipment of Pu and MOX fuel."[67] It cites an environmental assessment of the import of Russian plutonium 238 which found that "fire alone is not a credible means of causing a release." "The probability of a severe ship collision, followed by a fire, is on the order of 1.0 x 10^{-8} per port call.(DOE 1993x:A-3)"

Probability statistics are not the best tool to establish the adequacy of a transport standard. In a paper presented to the International Maritime Organization's Special Consultative Meeting, Dr. Edwin Lyman, NCI scientific director, used the example of elastomer cask seals to illustrate the weaknesses of the type B standards.[68] The lid seals prevent the escape of radioactive gases from the cask following an accident. They will fail after exposure of a few hours to temperatures of 250 - 300 degrees C. However, the Type B thermal test is low enough so that the failure threshold is not reached. Therefore, "transport casks with elastomer seals are able to be qualified as Type B packages . . . the current regulations do not require the cask designer to determine the conditions which *would* cause the seal to fail and ensure that a large safety margin is present."[69] 41/10.00.00

A 1992 report by ECO Engineering[70] also challenges the adequacy of Type B standards. The ECO report states, "Marine accidents involve significant forces and outcomes that appear to exceed the limits of the standards to which the casks are designed."[71] The report describes fire, collision, immersion and sabotage as events that could cause the casks to fail.

[66] DPEIS, p. G-4.

[67] DPEIS, p. G-5.

[68] "Addressing Safety Issues in the Sea Transport of Radioactive Materials," by Edwin S. Lyman PhD, Scientific Director, Nuclear Control Institute, presented to the IMO Special Consultative Meeting, March 4-6, 1996, London, England.

[69] Lyman, Ibid., p. 5

[70] "A Review of the Proposed Marine Transportation of Reprocessed Plutonium from Europe to Japan," ECO Engineering, March 30, 1992, prepared for Nuclear Control Institute and Greenpeace International.

[71] Ibid., p. 4.

M-281

10 00 00 Comment Number 40

The potential for a maritime accident was estimated based on several existing studies and data. The probability of a maritime accident would be small on the order of 1.0×10^{-8}/yr to 1.0×10^{-7}/yr, not per port call. DOE has considered the commentor's comments, but DOE remains convinced that the probability numbers were correctly stated in the Draft PEIS and therefore are included in the Final PEIS.

10 00 00 Comment Number 41

Both Pu and MOX fuel would be transported in Type B packages that have been fully tested and certified for these materials, as required by Federal law. DOE, as a responsible shipper of hazardous materials, will comply with stringent Federal packaging requirements. It is noted that there is some controversy concerning the adequacy of the Type B packaging. However, these packages are currently certified as safe for transporting radioactive materials. If the safety certification for the packaging is withdrawn, then new analyses will be required. Acknowledgment of this controversy has been included in Appendix G of the Final PEIS.

> The duration and intensity of shipboard fires, the enormity of the energy levels associated with ship collisions, and the extent of hydrostatic pressure of the ocean depths, to say nothing of the consequences of acts of terrorism, would appear to create exposure environments beyond the limits of the casks designed in accordance with IAEA standards.[72]

Sandia National Laboratories complained, in a rebuttal to the ECO report, that the accident conditions described in the ECO report exceed IAEA regulations. "Both U.S. and IAEA regulations make it clear that while the certification tests represent severe accident conditions, they do not represent maximum credible accident conditions,"[73] Sandia wrote. In its response, ECO wrote it "did not intend to impute such claims to the regulations. Rather ECO's intent was to point out the potential for severe accidents occurring that might breach containment of a Type B packaging."[74] 41/10.00.00 cont.

Given the amounts of plutonium and MOX that could be transported for disposition, it would be prudent to test the shipping casks to failure and to evaluate the findings in the PEIS.

V. Economic Issues

Like the non-proliferation analysis, the cost analysis of plutonium disposition options now being prepared by Oak Ridge National Laboratory must be integrated into the NEPA decision-making process. That analysis must include all costs of the various disposition options, including subsidies being demanded by nuclear electrical utilities that have expressed interest in using weapons-plutonium MOX fuel.

Given recent regulatory changes and the severe diseconomics of nuclear electricity generated at some facilities, these utilities face strong competition from non-nuclear electrical generators. An industry technical analysis fully anticipates that some utilities will insist upon not simply compensation for direct costs related to warhead plutonium disposition in their reactors, but subsidization of the electricity these reactors produce to guarantee that it is economically competitive with electricity from alternative non-nuclear sources, a subsidy that could cost U.S. taxpayers billions of dollars over the life of the 42/07.00.00

[72] Ibid., p. 10.

[73] "Safety of Shipments of Plutonium By Sea, U.S. Department of Energy, September 1993, Appendix B, "Review of the ECO Engineering, Inc. Report," by Sandia National Laboratories, p. 1.

[74] "Clarification for Appendix B of the Study: "Safety of Shipments of Plutonium by Sea," DOE/EM-0103, September 1993

M-281

07 00 00 Comment Number 42

In the *Technical Summary Report for Surplus Weapons-Usable Plutonium Disposition* potential fees to reactor owners for existing LWRs to use MOX fuel were noted. The exact fees were not included in the report since there is no firm basis on which to estimate these fees that would result from a business negotiation between the Government and the reactor owner. The technical analysis, along with the cost and schedule analyses, will be part of the decisionmaking process to support the ROD.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC, PAUL LEVENTHAL
PAGE 24 OF 47

plutonium-disposition program.[75] These costs must be carefully calculated in advance, so that they can be taken into account in the decision on disposition alternatives. 42/07.00.00 cont.

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[75] One study calculates that such a subsidy may run as high as six cents per kilowatt-hour, depending upon the utility and plants, equivalent to billions of dollars. GE Nuclear Energy, Study of Plutonium Disposition Using Existing GE Advanced Boiling Water Reactors, NEDO-32361, Prepared for the U.S. Department of Energy, June 1, 1994, p. 1.2-4.

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**COMMENTS ON THE DEPARTMENT OF ENERGY'S
STORAGE AND DISPOSITION OF WEAPONS-USABLE FISSILE MATERIALS
DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT**

Public and Occupational Health and Safety Issues

Submitted by

**Edwin S. Lyman, PhD
Scientific Director
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June 7, 1996

Strategies for stopping the spread and reversing the growth of nuclear arms.

Paul L. Leventhal, *President*. Peter A. Bradford, David Cohen, Denis A. Hayes, Julian Koenig, Sharon Tanzer, Roger Richter, Dr. Theodore B. Taylor
BOARD OF DIRECTORS

M-281

TABLE OF CONTENTS

Introduction	1
Inconsistencies in the DPEIS Health and Safety Methodology	2
Incompleteness of accident evaluation criteria	2
Absence of explicit evaluation of can-in-canister immobilization options	4
Absence of evaluation of incremental accident impacts of the existing LWR option	5
Incorrect analysis of "avoided human health impacts"	5
Inappropriateness of 80-km limit for consideration of public health impact	
Serious Flaws in the Safety Analysis of Reactor Options	6
Inadequacy of the evolutionary LWR accident analysis in general	8
Inadequacy of the evolutionary LWR accident as an upper bound for existing LWR accidents	9
Beyond design-basis accident consequences	10
Beyond design-basis accident probabilities	15
The role of economics in safety assessment	20
Conclusions	20

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June 7, 1996

**Comments on the Department of Energy's
Storage and Disposition of Weapons-Usable Fissile Materials
Draft Programmatic Environmental Impact Statement**

Public and Occupational Health and Safety Impacts of
Plutonium Disposition Alternatives

Conversion of surplus weapons-usable plutonium (WU-Pu) to the spent fuel standard can provide a great benefit to disarmament and non-proliferation, especially if there is reciprocal action on the part of Russia. However, this significant benefit comes at a price. All disposition options under consideration in the DPEIS involve multi-year campaigns involving large-scale processing of WU-Pu and other extremely hazardous radionuclides. Furthermore, for the large fraction of surplus WU-Pu that is now in the form of weapons components, WU-Pu in relatively stable solid form must be converted to highly dispersible intermediate process streams and subjected to a number of energetic processes such as oxidation and treatment at high temperature. Because of the possibility of a catastrophic accident in a processing facility or during irradiation in a nuclear reactor, the implementation of disposition will be associated with a substantial increase in the risk of dispersal of a large quantity of WU-Pu.

For this reason, a major objective of the DPEIS should be the presentation of a thorough and consistent evaluation of the occupational and public health risks of different WU-Pu disposition options. Disposition options should be ranked according to the risks that they pose, and this ranking should play an important role in the final selection. 43/09.09.08

It has often been argued that environmental impacts need not be a decisive factor in choosing a WU-Pu disposition option because the risks of any option will be small compared to those incurred when the WU-Pu was produced. However, this argument in no way negates the desirability of strictly limiting further harm from the aftermath of the Cold War. If the opportunity now exists to carry out the disposition program in a way that minimizes health and safety impacts, common sense dictates that the lowest-impact option should be given the most serious consideration, assuming it is not disqualified by other factors such as deleterious non-proliferation impact or excessive cost or delay. 44/08.03.01

The DPEIS, however, fails to accomplish this objective. The methodology it uses for evaluating and comparing the safety risks of different disposition options is logically inconsistent and confusing. Furthermore, possibly as a consequence of the large number of different groups involved in its preparation, it contains contradictory factual information. The errors and questionable assumptions in the documents referenced by the DPEIS cast 45/09.09.08

M-281

09 09 08 Comment Number 43

Potential human health impacts from Proposed Actions are analyzed and documented in this PEIS as required by NEPA. To inform the public and decisionmakers, all latent cancer risks associated with the alternatives are presented in the PEIS regardless of their risk magnitude. The ranking or decisionmaking analysis of the alternatives will be based on various factors including human health impacts. DOE's intent in the PEIS is to provide an unbiased environmental analysis of all alternatives. However, the Reactor Alternatives generally do have more available information than other disposition alternatives because of industry experience.

08 03 01 Comment Number 44

Comment noted.

09 09 08 Comment Number 45

Based on comments received from the public and other reviewers, revisions have been made to the PEIS to clarify information that was incorrect or unclear. These revisions appear in the Final PEIS.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 28 OF 47

considerable doubt on its quantitative accuracy. 45/09.09.08 cont.

The most problematic consequence of the inconsistencies plaguing the DPEIS analysis is an exaggeration of the risks of the immobilization options relative to the reactor-based options. This must be corrected in the final version in order to provide a fair presentation of the evaluation and ranking of the safety risks of the various options. 43/09.09.08 cont.

Such a presentation would show that the health and safety impacts of the immobilization options will be substantially lower than those of the reactor options. However, as shown below, the DPEIS is structured to minimize the significance of this fact. Whether deliberate or not, this has the effect of biasing the whole document toward the reactor options.

1. Inconsistencies in the DPEIS health and safety methodology

a) Incompleteness of accident evaluation criteria

In Section M.5.1.1., it is stated that "the potential for facility accidents and the magnitudes of their consequences are important factors in the evaluation of ... storage and disposition alternatives," and that "the health risk issues are twofold." These two issues are identified as 1) whether accidents at any of the facilities pose unacceptable health risks to workers or the public, and 2) whether alternative locations for facilities can provide lesser public or worker health risks.

This list of issues to be considered in evaluating accident impacts of disposition is clearly incomplete. In particular, the question of whether alternative *disposition options at a given location*, rather than alternative *locations*, can provide "lesser public or worker health risks" does not seem to be regarded in the DPEIS as a worthy criterion for consideration. This is confirmed by the absence of a graph in the Summary comparing accident impacts of different options. But such a comparison is clearly legitimate and meaningful, and therefore essential. 46/09.09.08

Discounting the relevance of the comparative accident impacts of different disposition options biases the DPEIS analysis toward the reactor options. This is not completely clear from the data provided by the DPEIS itself. According to the DPEIS, the *maximum* risks of cancer fatalities to workers and the public resulting from accidents at a plutonium vitrification facility are two to three orders of magnitude below those resulting from accidents involving evolutionary LWRs (Ev-LWRS).[1] On the other hand, data in the DPEIS implies that the *expected* risks, computed by weighting the consequences of individual accident sequences with their expected probabilities, are comparable for the two 47/09.09.08

[1] Storage and Disposition DPEIS, Attachment B, Pg. S-150.

M-281

09 09 08 Comment Number 46

The health impacts from accidents are very difficult to compare using bar graphs. The bar graphs distort the relative health impacts among the alternatives (for example, a normally small number appears large when compared with a very small number). Therefore, to avoid confusion, the comparison bar graphs were not used in the Final PEIS.

09 09 08 Comment Number 47

The health risk assessment from the potential accidents in this PEIS is analyzed to "envelope" the potential accident impacts ranging from high probability-low consequence to low probability-high consequence. Although it is believed that the health risk from all potential accidents would fall within this "envelope," it is difficult to identify all of potential individual accidents for all of the proposed facilities since most of the proposed alternative facilities are still in early development stages. The risks for the accidents are calculated based on the health effects from the set of the accidents analyzed for each alternative in the PEIS. Whether the set of accidents selected covers all potential accidents for the facility depends on the complexity of the facility and the maturity of the design. Therefore, it is not appropriate to compare the risks for the accidents between the alternatives. However, it can be used for comparing the facility accident impacts among different sites within an alternative since they use the same set of the accidents. The expected risk was not used for the summary comparison of the alternatives. The PEIS provides the consequences, probabilities, and risk of the utilization of MOX fuel for Pu disposition.

options. However, when the many problems with the DPEIS accident analysis are corrected, as detailed below, we expect that the immobilization options will prove to have significantly lower impacts than the reactor options with respect to all measures of accident severity, including "expected" risks. 47/09.09.08 cont.

The DPEIS downplays the significance of "discernible differences [in health and safety impacts] among alternatives" by stressing that although in some cases the potential accident risks of the immobilization options are indeed much lower than those of the reactor options, "the risks associated with implementing any of the alternatives is small,"[2] a statement provided without adequate justification. Particularly problematic is the use of generic probabilistic risk assessment (PRA) results to provide values for the absolute accident risks of different options. It is widely accepted that while PRAs are useful in understanding comparative risks, e.g. how modifications to a particular plant can improve safety, they are far less useful (and credible) in generating values of absolute risk. 48/09.09.08

The credibility of the absolute risk values cited in the DPEIS is further damaged by the numerous errors, omissions and inconsistencies contained in the analysis of reactor accidents (especially in existing LWRs), which could lead to an underestimation of the actual risks of using MOX by several orders of magnitude. Some of these are described in more detail below. 49/09.09.08

The DPEIS does not explain its risk methodology clearly. A section on "risk" purports to argue that the risks from accidents during plutonium disposition should be considered in the context of other, more common risks, such as death from accidental poisoning. However, even this discussion is misleading since it uses as an example a comparison of the *annual* risk from a plutonium storage accident (itself one of the smallest accident risks tabulated in the DPEIS) over the *lifetime* risks from these more common hazards, thereby overstating them by a factor of 70.[3] If, for instance, one considers the annual risk as a result of an accident at an Ev-LWR, the difference between the risks of the reactor disposition option and the "common risks" cited in the DPEIS are not as striking. The (lifetime) risk from accidental poisoning, according to the DPEIS, is 1/1000, so the annual risk is 1.4×10^{-5}; the expected risk from an Ev-LWR accident at the Oak Ridge plant is given as 1.2×10^{-4} (pg. M-366). If this value were adjusted to correct for the underestimation by several orders of magnitude of volatile and semi-volatile releases in a beyond-design-basis accident (see below), it becomes apparent that some of the activities listed in the DPEIS can have risks approaching the so-called "common" risks. 50/09.09.08

Although it can be useful to put the absolute risks of disposition activities into perspective, this should not be used to obscure the fact that the immobilization options provide minimum-risk alternatives for WU-Pu disposition. 43/09.09.08 cont.

[2] Storage and Disposition DPEIS, Section M.5.1.1.2, p. M-226.

[3] Storage and Disposition DPEIS, Section M.5.1.1.1, p. M-225.

09 09 08 Comment Number 48

Both the human health consequences (potential cancer risk for the MEI of public and worker and latent cancer fatalities to the general public) from the postulated accidents and the frequency of the accident occurrence are evaluated and reported in the PEIS. The health effects from potential accidents in this PEIS are not based on the facility probabilistic risk assessment (PRA). At this programmatic level of NEPA review for disposition, specific disposition facilities are not being proposed so as to support a facility-specific PRA. Additional facility-specific analyses would be provided in subsequent tiered NEPA review.

09 09 08 Comment Number 49

In response to public comment, the accident analyses for existing LWRs has been modified in the Final PEIS.

09 09 08 Comment Number 50

Section M.5 of the PEIS contains evaluation methodologies and assumptions used in analyzing facility accidents. The discussion presents the risks in terms of the commonly used units ascribed to each risk. The information provided is not meant to imply that risks of a latent cancer fatality caused by DOE operations are trivial, but rather to show how they compare with other more familiar risks. Based on comments received from the public and other reviewers, revisions have been made to the PEIS to clarify information that was unclear. These revisions appear in the Final PEIS.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 30 OF 47

b) Absence of explicit evaluation of can-in-canister immobilization options

Some of the WU-Pu disposition options under consideration in the DPEIS can be implemented in a variety of ways. In Volume I, Section 2.4, p. 2-76, the methodology that was used for determining which variant of a particular disposition option should be chosen for full evaluation in the DPEIS is discussed. In particular, it is stated that "bounding" variants were selected, e.g. those which were likely to have environmental impacts equal to or greater than all the other variants under consideration. This approach was used to explain why only the "greenfield" immobilization options that require a new, shielded immobilization plant were explicitly analyzed, rather than the options that "piggyback" on operations at existing facilities, such as the can-in-canister (CIC) approach at the Defense Waste Processing Facility (DWPF) at the Savannah River Site (SRS). The CIC approach will have lower environmental impacts than greenfield approaches because in the latter approach, only the incremental risks associated with WU-Pu immobilization would be charged to the disposition program. 51/05.00.08

This could be a legitimate approach, provided that it were consistently applied, which is not the case in the DPEIS. The DPEIS evaluates reactor options that require construction of new, evolutionary LWRs (Ev-LWRs) *and* those involving irradiation of MOX fuel in existing LWRs (Ex-LWRs) (except in the important category of accident impacts). This is apparently not judged in the DPEIS to be inconsistent with the approach used for immobilization options because it treats the reactor proposals as different "options," rather than variants of the same option. However, this is merely a semantic distinction. 52/05.00.08

Because only incremental impacts are considered in the Ex-LWR case, but not in any of the immobilization options, the reader can get the misleading impression that the Ex-LWR reactor option could have comparable or even lower normal radiological impacts than *any of the immobilization options* (e.g. Summary, Figs. S-17 and S-18; Attachment B, pgs. S-142 to S-145) and can even provide a net benefit (although this benefit disappears when the impacts of MOX fabrication are considered). The DPEIS even goes as far as to include a section on the incremental benefits of using MOX fuel in reducing the health impacts of the nuclear fuel cycle, a section which is completely irrelevant to the particular mission of WU-Pu disposition and is completely wrong as well (see below). 53/09.09.08

For consistent treatment of "incremental" radiological impacts, there should be a comparison of the Ex-LWR options with the CIC options. In these options, plutonium first would be immobilized in glass or ceramic, without the addition of cesium-137 for spiking purposes, and packed in small cans. These cans would then be placed in the DWPF canisters prior to filling with HLW glass. The incremental environmental impacts of this approach would be those associated with operation of the plutonium immobilization line only (assuming that the introduction of the small cans would not have a detrimental effect on DWPF operations, as results from cold testing of CIC at DWPF clearly indicate). 54/09.09.08

M-281

05 00 08 Comment Number 51

Comment noted. Appendix O, *Can-In-Canister Variants*, was added to describe the variant of the Vitrification Alternative.

05 00 08 Comment Number 52

Comment noted.

09 09 08 Comment Number 53

The human health impacts are presented for both the existing condition (No Action) and the action alternatives in the PEIS, including the Existing LWR Alternative. (The health impacts from potential accidents for all three Reactor Alternatives using MOX fuels are presented in the Final PEIS.) Incremental impacts are those impacts from each alternative over the existing conditions. In response to public comment, Section 4.3.5.2.9 of the Final PEIS has been revised to show incremental and total impact. For normal operations and accidents, both incremental impacts and total impacts are presented in the PEIS for each reactor disposition alternative. Also, an inclusion of potential avoided environmental impacts is appropriate to the NEPA process; however, in response to public comments, this section has been revised.

09 09 08 Comment Number 54

The can-in-canister variant is one of a number of potential applications of the Vitrification Alternative. The environmental impacts of the can-in-canister variant, which uses the same facilities as the Vitrification Alternative, are bounded by the impacts of the vitrification analysis shown in the PEIS. Appendix O, *Can-In-Canister Variants*, was added to describe this variant of the Vitrification Alternative.

One can show, using figures given in the DPEIS, that the incremental normal radiological impacts of CIC options would be about two orders of magnitude smaller than those from a greenfield immobilization facility. This can be seen most easily by comparing the doses received by the public from normal operation of the ceramic immobilization facility in the deep borehole option, in which case no cesium-137 is used, and those from a greenfield ceramic immobilization facility, in which case cesium-137 is added directly to the ceramic during processing. From Tables M.2.9-3 and M.2.9-4 of the DPEIS, one sees that routine emissions of plutonium from ceramic immobilization facilities located at SRS account for about 4% and 2% of the total dose to the maximally exposed individual (MEI) and the committed effective population dose equivalent, respectively, the rest being due to Cs-137 emissions. 54/09.09.08 cont.

Similar reasoning can be applied to the accident analysis of greenfield immobilization facilities given in the DPEIS to extract the incremental risks associated with CIC. For example, the annual risk to the MEI from accidents at a greenfield vitrification facility at SRS is 1.1×10^{-10}, according to Table M.5.3.5.2-6. To obtain the incremental impacts of the CIC approach, one should only consider accidents resulting in releases of plutonium and subtract the doses due to Cs-137 releases. This approach yields an annual risk from CIC to the MEI at SRS of 1.6×10^{-12}, about a factor of one hundred smaller than the greenfield risk.

Because the CIC approach has significantly smaller radiological impacts than the greenfield immobilization, and because it is analogous to the Ex-LWR option, it should be treated as a distinct option and fully evaluated in the PEIS. 5/01.02.00 cont.

c) Absence of evaluation of incremental accident impacts of the existing LWR option

The DPEIS assumes that there are no incremental accident risks associated with the substitution of MOX for low-enriched uranium (LEU) in Ex-LWRs, which makes this option appear to be essentially zero-risk. This statement is simply not justifiable for a number of reasons which are discussed in detail below. In fact, the incremental accident risk of this option may well exceed the absolute risk of the Ev-LWR option. 49/09.09.08 cont.

d) Incorrect analysis of "avoided human health impacts" due to substitution of MOX for LEU

Volume II, Section 4.9 of the DPEIS is entirely wrong and should be corrected or deleted from the final version. In attempting to compare the risks of the MOX and LEU fuel cycles, the authors of the section seem to have forgotten that MOX fuel is about 95% uranium. Thus it is completely wrong to claim, as they do, that there are no health impacts associated with the uranium mining, milling and conversion stages in the MOX cycle. The stage of the cycle which is bypassed is uranium enrichment, which is well-known to have very low health impacts anyway. 55/09.09.08

09 09 08 Comment Number 55

Depleted uranium (independent of the HEU disposition), which is currently in the DOE stockpile, is assumed to be used to blend Pu into MOX fuel. Since no new uranium mining, milling, conversion, or enrichment would be needed to produce MOX fuel, the impacts of these uranium fuel cycle steps would be avoided.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 32 OF 47

Although not explicitly stated, the authors may be assuming that depleted uranium stockpiles will be used to fabricate MOX fuel, in which case the associated mining and milling steps (but not conversion) will be avoided. This is a legitimate point, but by the same reasoning, one can also give credit to stockpiles of uranium that can be used in the LEU route, such as LEU obtained from the blend-down of surplus HEU. The relatively small amount of electricity that would be generated from MOX fuel fabricated from surplus warhead plutonium could easily be displaced by the LEU equivalent of about 30 tonnes of HEU. Thus one cannot consistently assign an incremental health benefit to the US MOX program. 56/09.09.08

e) Inappropriateness of 80-km limit for consideration of public health impact

The restriction of evaluation of public health impacts to within an 80-km radius of the facility in question leads to some peculiar inconsistencies in the comparison of immobilization and MOX options. For instance, according to the DPEIS the CANDU option appears to have no public health impacts on the U.S. population, other than those resulting from the small risk associated with the production and transport of MOX fuel within the U.S. Yet a quick look at a map reveals that a release of radiation from the Bruce A station in Ontario would most likely affect a large portion of the northeastern United States, although mostly at distances greater than 80 km. 57/09.09.08

Furthermore, the 80-km truncation conceals the fact that a large-scale reactor accident can have national and even global impact, whereas an accident at an immobilization facility would in all likelihood be much more limited in geographical range. This is because both the source term and the energy available for dispersion would be much smaller in the case of the immobilization facility. Thus truncating consideration of public health impacts at 80 km greatly overestimates the risks associated with immobilization compared with MOX.

2. Serious flaws in the safety analysis of reactor options

The health and safety analysis of the MOX options in the DPEIS contains such serious flaws that DOE should discard the analysis as written and start over, proceeding in a clear and logical manner. The use of MOX in LWRs or CANDUs -- in particular, full-core MOX utilizing weapons-grade plutonium as proposed in the DPEIS -- is a novel practice associated with numerous unsolved and potentially very serious safety risks. Experience with LWR MOX use in other countries, which is often cited by promoters of the MOX options, is of limited applicability to the planned US program because the foreign programs utilize plutonium with different isotopic contents, lower MOX core fractions, and fuel without integral burnable absorbers. In addition, experience to date with the use of MOX has revealed a number of significant safety issues which remain unresolved. The existing LWR (Ex-LWR) option, which is probably the MOX option most likely to be chosen, must be singled out for special concern. Yet the DPEIS contains no accident analysis specific to this option. 49/09.09.08 cont.

M-281

09 09 08 Comment Number 56

The depleted uranium for the MOX fuels is already in DOE's stockpile and is independent of the DOE's HEU disposition program.

09 09 08 Comment Number 57

Like any other EIS, a realistic impact area has to be defined to conduct a radiological impact assessment. Federal guidance defines two major impact regions. NUREG-0654 defines 16 km (10 mi) as the plume exposure region and 80 km (50 mi) as the ingestion exposure region for the nuclear facility accident emergency planning zone. While populations at greater distances may receive some exposure from an accidental release of radioactive material into the environment, this exposure would be considerably less than the exposure to the population within the 80-km (50-mi) region. Also, extending the assessment to further distances would introduce greater analytical uncertainties to the calculated impacts.

It is acknowledged that, if the source term was very large, the boundaries chosen could be extended. Nevertheless, NUREG guidance is an appropriate and reasonable choice for NEPA analysis.

The DPEIS dispenses with fundamental issues of MOX safety in one paragraph, in which it alludes to "separate studies" (which were mistakenly left unreferenced) that "indicate that the use of MOX fuel in a ... LWR does not increase the risk and consequences of accidents."[4] Most of these source documents turn out to be studies based entirely on reactor vendor analyses which purport to confirm the safety of using MOX in their reactors. However, at least one of the reactor vendors freely admitted to us that its in-house analyses were biased and unreliable.[5] Closer examination of these studies reveals that they in no way provide adequate justification for the above statement in the DPEIS. In fact, at least one of the references, the National Academy of Sciences study "Management and Disposition of Excess Weapons Plutonium: Reactor-Related Options," actually contradicts the statement, by estimating that the consequences of a severe accident could increase by 10-20% as a result of the substitution of MOX for LEU. Such an increase, far from being insignificant, could overwhelm the radiological impacts of any of the other disposition options. Furthermore, the discussion below indicates that the NAS may have underestimated the incremental consequences. 58/09.09.08

DOE may have judged that this shoddy and incomplete accident analysis was sufficient for the purposes of the DPEIS because, if the MOX option were chosen, safety issues would be dealt with later in the context of NRC review of the procedure. However, this defeats the purpose of the whole exercise, which is to inform decision-making with an accurate comparative assessment of risks. To conform to the spirit of NEPA, a deeper understanding of the potential risks involved with the use of MOX in LWRs in this country must be acquired prior to the public comment period and should not be deferred until after decisions are made. The NRC and independent experts should be brought in at the DPEIS stage to provide alternative perspectives on the outstanding safety issues. This would be a prudent course of action, since unanticipated safety questions that arise later in the process could serve to cause unacceptable delays in disposition. 59/08.03.00

The only DPEIS reactor alternative for which any information concerning accident impacts is provided is the Evolutionary LWR (Ev-LWR) option. In the Summary, the reader is informed that "comparable data are not available" for the existing (Ex-LWR) option. DOE may be assuming here that the accident impacts of the Ev-LWR option bound those of the Ex-LWR, since the full impact of an accident would have to be charged to plutonium disposition in the former case, whereas in the latter case, one only need consider incremental impacts, e.g. the difference in risk between an existing reactor fueled with MOX and the same reactor fueled with LEU. Since the DPEIS claims without justification that there is no difference in risk, it implies that the Ex-LWR is a zero-risk option. However, this logic is faulty and renders the accident analysis in the DPEIS unusable for decision-making purposes. 49/09.09.08 cont.

[4] DPEIS, Volume II, pg. 4-690.

[5] Personal communication with General Electric executive, September 1995.

M-281

09 09 08 **Comment Number 58**

The impacts and risks associated with the use of MOX fuel in existing commercial LWRs and in evolutionary LWRs have been reanalyzed. The results, which have a quantitative basis, are presented in Sections 4.3.5.2.9, 4.3.5.4.9, and M.5.3.10 of the Final PEIS.

08 03 00 **Comment Number 59**

The Department of Energy acknowledges the commentor's concern about the accident analysis used in the PEIS for the Reactor Alternatives. The accident analysis is at a level of detail and specificity needed for a programmatic decision on the disposition of weapons-usable fissile materials. Additional analysis for three cases of accident release scenarios was added to Section 4.3.5.2.9 of the Final PEIS. Impacts for one case are shown in Table 4.3.5.2.9 of the Final PEIS. Further detailed, technology-specific accident analysis will be included in the subsequent tiered NEPA review.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC, PAUL LEVENTHAL
PAGE 34 OF 47

a) Inadequacy of the Ev-LWR accident analysis in general

Before addressing whether the risk values resulting from the LEU-fueled Ev-LWR accident analysis contained in the DPEIS are also valid for a MOX-fueled Ex-LWR, it should be pointed out that these values are inaccurate even for the case to which they are supposed to explicitly pertain. The Ev-LWR analysis included in the DPEIS greatly understates the potential risks of an accident involving a LEU-fueled LWR, even one of "evolutionary" design. The "evolutionary" designs, such as the GE ABWR, do not contain the advanced safety measures, such as those proposed for the European Power Reactor, which would nearly eliminate the risk of a catastrophic off-site release of radiation (e.g. a double containment structure), and thus are still vulnerable to such events. However, Ev-LWR vendors claim that the risk of such events will be greatly reduced relative to the current generation of Ex-LWRs. 49/09.09.08 cont.

The most severe Ev-LWR beyond design-basis accident included in the DPEIS is an anticipated transient without scram (ATWS), followed by loss of core cooling, core meltdown, and late containment failure. The frequency of this accident is listed as 1.7×10^{-7} per reactor-year. However, the associated radionuclide source term, which references the General Electric Advanced Boiling Water Reactor (ABWR) Safety Analysis Report and studies prepared by a consultant for another purpose, is much smaller than that which could conceivably result from a loss-of-containment accident.[6]

For instance, the postulated release of Cs-137 to the environment is 230 curies (Ci), which is seen to correspond to a release fraction of 1.8×10^{-5} when compared to the end-of-cycle Cs-137 Ev-LWR core inventory of 1.3×10^{7} Ci given in a source document (which itself reference ABWR safety analyses).[7] This release is substantially below the maximum possible release of cesium, which is semi-volatile and can be almost completely evolved from the core during a meltdown. It is now accepted that 20-40% of the cesium core inventory was released to the environment during the Chernobyl accident. 60/09.09.08

In fact, if one looks at the entire ABWR severe accident spectrum, which does not appear in the DPEIS but is included in one of the source documents,[8] one sees that the Cs release fraction can be as great as 3.5×10^{-1} in a certain class of accidents known as Release Class (RC) 5, whereas a release of 2×10^{-5} in the DPEIS accident appears to corresponds to

[6] DPEIS, Volume III, Appendix M, Table M.5.3.8.1-2, p. M-361.

[7] LLNL 1996g, *op. cit.* Table 8-1, p. 8-10. Although the Cs-137 value cited above is reasonable, one should note that this table is otherwise unreliable, with some entries clearly wrong (e.g. a core inventory of 5.4×10^{5} Ci, or 8.7 MT, of Pu-239, is given for a LEU-fueled Ev-LWR), and others inconsistent with values given in the DPEIS (for instance, a release of 4.4×10^{4} Ci of Kr-85 is postulated in the DPEIS, whereas the core inventory in Table 8-1 is only 1.2×10^{4} Ci). Inconsistency among the various source documents is a general feature of the DPEIS.

[8] LLNL 1996g, Table 8-5, p. 8-14.

M-281

09 09 08 Comment Number 60

The impacts and risks associated with the use of MOX fuel in existing LWRs has been reanalyzed. The analysis is in accordance with DOE, Office of NEPA Oversight guidelines for the preparation of EISs (*Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements U.S. Department of Energy, Office of NEPA Oversight*, May 1993). The guidelines require an assessment of impacts due to potential severe accidents which have frequencies of occurrence in the range of 1.0×10^{-7}/yr to 1.0×10^{-6}/yr. The guidelines state that, as a practical matter, events with probabilities less than 1.0×10^{-7}/yr will rarely need to be examined. The analysis was based on the best available information at the time the Final PEIS was prepared. The results of the analysis, which have a quantitative basis and utilize the Melcor Accident Consequence Code System (MACCS) code, are presented in applicable sections of the Final PEIS. The analysis includes a determination of the sensitivity of americium, curium and Pu to the risk dominant accident doses for a commercial MOX fueled reactor and the results are described in the Final PEIS.

While cesium-137 (Cs-137) source terms from extraordinary reactor accidents (Reactor Class 5 accidents) may exceed release fractions analyzed in the PEIS, the beyond design basis accident selected for analysis (Reactor Class 2 accident) has a frequency of occurrence of 1.3×10^{-7}, which is consistent with NEPA guidelines. While Chernobyl accident releases of Cs-137 may have exceeded 20 to 40 percent of the cesium core inventory, such release fractions are not applicable to U.S. LWRs. The analysis of severe accidents (Reactor Class 5 accidents) is appropriate for PRAs or Safety Analysis Reports (SAR). Should the Reactor Alternative using MOX fuel be selected as the Preferred Alternative, subsequent tiered-NEPA documents or SARs will be prepared on site-specific bases.

The PEIS was modified in Section 5.3.11 to include a review of the radioisotopes discussed in the Sandia report. This report discussed using the MACCS code for curium and other transuranic radioisotopes. The contribution of americium (Am-241), curium (Cm-242 and Cm-244), and plutonium (Pu-238, Pu-239, Pu-240, and Pu-241) was added to the accident section of this PEIS.

a Release Class 2 event, which is said to occur with a frequency of 1.3×10^{-7}. There is a similar disparity in iodine release fractions between RC5 and RC2. RC2 is also characterized by zero release of other semi-volatiles (e.g. Te, Ru) and low-volatiles (e.g. Sr and Ba). While the RC5 release fraction is a factor of 20,000 greater than the one assumed in the DPEIS, the associated accident frequency is listed as 2.2×10^{-4}, which is only a factor of ten smaller. Thus the risk of the RC5 accident (e.g. probability times consequences) due to cesium emission is on the order of one thousand times greater than that of the DPEIS accident. Of the eight release classes listed, four have larger risks associated with them than RC2, the one included in the DPEIS. There is no legitimate basis for excluding these other accidents from consideration. However, their exclusion artificially underestimates the potential environmental impacts of reactor disposition relative to the immobilization options, leading to erroneous conclusions.

b) Inadequacy of the Ev-LWR accident as an upper bound for Ex-LWR accident impacts

There are two interrelated reasons why the Ev-LWR accident analysis in the DPEIS cannot be considered to be bounding or conservative with regard to the potential accident impacts of the MOX options. 60/09.09.08 cont.

First, it is based on analysis of an Ev-LWR fueled with LEU instead of MOX, and thus completely sidesteps the complex but crucial issue of whether and to what extent severe accident parameters, such as core damage frequencies (CDFs) and source terms, may differ for an Ev-LWR fueled with full-core MOX rather than LEU.[9]

Second, the Ev-LWR analysis contains numerous assumptions with regard to safety features which are specific to advanced reactor designs and simply do not apply to the MOX options based on use of existing LWRs (Ex-LWR) or CANDUs. For instance, advanced LWRs are assumed to have CDFs at least an order of magnitude smaller than those associated with LWRs operating today. Also, the source terms employed in the beyond design-basis accident analyses are based on assumptions about the likelihoods of various accident scenarios which are indisputably invalid for currently operating reactors (and may not even be valid for Ev-LWRs, which to date exist largely on paper).

To assess whether the Ev-LWR case is bounding or not with respect to accident impacts, one must determine, in light of these two factors listed above, whether the incremental risks of substituting MOX for LEU in Ex-LWRs may actually exceed the absolute risk values for (LEU-fueled) Ev-LWR operation provided in the DPEIS. The best way to do this consistently would be to derive complementary cumulative distribution 61/09.09.08

[9] Although one of the main references for the DPEIS section on Ev-LWR safety is a document (Evolutionary/Advanced Light Water Reactor Data Report, UCRL-ID-123411, February 1996), which does contain some discussion of the differences between MOX and UO_2 source terms, this information is apparently not used in the DPEIS for the development of accident risk values. Instead, data from two other documents which refer exclusively to UO_2-fueled LWRs are used.

M-281

The PEIS recognizes that there are uncertainties in the methodology for accident analysis as described in Section 4.1.9. There are additional uncertainties in the difference in reactor-grade versus weapons-grade MOX fuel. Although there is no experience in the United States for a full MOX core, DOE will consider a full MOX core only after evaluating lead test assemblies and/or a partial MOX core with weapons-grade material. This evaluation will reduce technical uncertainties between reactor-grade and weapons-grade MOX fuel. In addition, before a partial or full core can be utilized in a reactor, a reactor-specific safety analysis will be performed analyzing the use of weapons-grade MOX fuel.

09 09 08 Comment Number 61

The human health impacts for both the existing condition (No Action) and the action alternatives are evaluated and presented in the PEIS, including the Existing LWR Alternative (The health impacts from potential accidents for the three Reactor Alternatives using MOX fuel are also analyzed.) The incremental impacts are those impacts from Proposed Actions over existing conditions at same site. For example, the incremental impacts of using the partially completed LWR would be represented by the total impacts because the LWR was not operated before. The incremental impacts of using the existing LWRs would be represented by the differences between using the proposed MOX fuel and the current UO_2 fuel.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC, PAUL LEVENTHAL PAGE 36 OF 47

functions (CCDFs) for all three options and compare them.

Determination of the incremental risks of the Ex-LWR option is bound to be an extremely difficult and uncertain exercise. However, it is central to the whole disposition question. The public will want to know if there is significant risk involved in introducing MOX into Ex-LWRs and whether there are safer alternatives. The DPEIS sheds no light on this question and therefore fails to accomplish its mission. 49/09.09.08 cont.

Rather than try to determine which alternatives are bounding and which are not, the PEIS should simply provide enough information to accurately carry out the following comparisons: the incremental risks of the CIC immobilization options vs. the incremental risks of the Ex-LWR option (evaluated in a technically justifiable manner), and the risks of the greenfield immobilization options vs. the risks of the greenfield reactor options. The absence of such comparisons in the DPEIS makes it extremely difficult for the reader to obtain a clear understanding of the relative environmental impacts of the reactor and immobilization options. 62/09.09.08

Below, we will discuss a number of issues which support the notion that the substitution of MOX for LEU in Ex-LWRs may increase both the consequences and the probabilities of severe accidents by significant factors.

1) Beyond design-basis accident consequences: the issue of low-volatile source terms

The question of whether the consequences of a beyond design-basis accident in an Ex-LWR (e.g. core meltdown and containment failure) would change significantly if the reactor were fueled with MOX instead of LEU depends on the relative radionuclide inventories of the two cores and the radiological impact of the differences. The primary distinction is that the in-core inventories of the transuranic actinides Pu, Am and Cm are all greater by substantial factors in MOX cores. The magnitude of these factors, which depends on the initial plutonium loading in the fuel, is approximately on the order of 3 for plutonium isotopes, 5 for americium isotopes and 4 for curium isotopes at the end-of-cycle. (For MOX fabricated with reactor-grade plutonium, the curium inventory is greater by an additional factor of 10). Neptunium inventories actually are smaller in MOX cores, but the difference is only about of a factor of two. Since these radionuclides are alpha-emitters with very high inhalation and ingestion radiotoxicities, and many have long half-lives, they can contribute significantly to the committed doses incurred following a reactor accident, especially via the ingestion and resuspension pathways, even if only a small fraction of the core inventory is released. 60/09.09.08 cont.

Using an argument dating at least as far back as GESMO, the Generic Environmental Impact Statement on the Use of Mixed-Oxide Fuel in Light-Water Reactors, DPEIS references claim that the increase in actinide inventories in a MOX core will not affect the consequences of an Ex-LWR accident because "plutonium and other insoluble

M-281

09 09 08 Comment Number 62

The Department of Energy determined that the bounding analyses for each of the disposition alternatives is an appropriate level of detail to support a programmatic decision. Site-specific environmental analysis of disposition technologies will be performed, as appropriate, for the next tiered NEPA documents. In response to public comment, Appendix O has been added which discusses the can-in-canister variant.

fuel isotopes are not included in the releases to the environment."[10] Thus according to this logic, it does not matter whether the inventory of actinides is greater in a MOX core because they are low-volatile species and will not be released to the environment even if the containment fails. 60/09.09.08 cont.

This argument is, plainly speaking, incorrect. There are circumstances under which significant releases of low-volatile radionuclides can occur.

First of all, the best possible laboratory for loss-of-containment accidents, the Chernobyl event, has demonstrated that significant and wide-ranging dispersal of non-volatile radionuclides is possible in beyond-design-basis accidents. The recently issued OECD review of the Chernobyl source term has concluded that the release fraction for low-volatile core constituents, including the actinides, was approximately 3.5%. Moreover, non-volatile fuel fragments were discovered as far away as Greece, over one thousand kilometers away.[11]

The often-repeated argument that a Chernobyl-type accident cannot happen here does not mean that the dispersal behavior of the Chernobyl core does not have relevance for Western LWRs, should they be subject to beyond design-basis accidents with loss of containment (provided that the differences in core melt chemistry are taken into account). In fact, the NRC has acknowledged in the past that low-volatile releases as high as several percent of core inventory were possible in such accidents and incorporated this information into its state-of-the-art LWR probabilistic risk assessment (PRA), NUREG-1150.[12] 63/09.09.08

The DPEIS relies on vendor documents to support its claim that the release of low-volatile radionuclides would be insignificant in a beyond design-basis Ex-LWR accident. For example, the LWR PEIS Data Report quotes release fractions to the environment taken from a Westinghouse Hanford Company report. For low-volatile radionuclides, these values are all extremely small (the largest is 0.3%). The report then claims that these values are consistent with NRC's latest rulemaking on the issue of core-to-containment release fractions, NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants."[13] 64/09.09.08

[10] Oak Ridge National Laboratory, *FMDP LWR PEIS Data Report*, Rev. 3, ORNL/MD/LTR-42, December 1995, p. B-22.

[11] L. Devell *et al.* "The Chernobyl Reactor Accident Source Term: Development of a Consensus View," OECD/NEA, OECD/GD(96)12. November 1995.

[12] US Nuclear Regulatory Commission, NUREG-1150, 1987.

[13] U.S. Nuclear Regulatory Commission, "Accident Source Terms for Light-Water Nuclear Power Plants," NUREG-1465, February 1995.

M-281

09 09 08 Comment Number 63

The human health impacts from the potential LWR accidents were analyzed and presented in this PEIS. The health impacts will be evaluated for full MOX cores of the existing, partially completed, and evolutionary LWRs, and results are documented in the Final PEIS. The Chernobyl reactor is intrinsically different from the LWRs designed and operated in the United States. The design (including containment system design) and operation of the nuclear power plants in the United States prevent the Chernobyl-type accident consequences to happen in the United States with a probability greater than 1.0×10^{-7}/yr. While a Chernobyl-type accident could result in higher radionuclide releases, the radioactive releases from the accidents analyzed in the PEIS reflect a beyond design basis accident within the probability of occurrence (1.0×10^{-7}) that is acceptable for NEPA purposes. Also, any probabilistic risk assessment for the Proposed Action is beyond the scope of this PEIS.

09 09 08 Comment Number 64

NUREG-1465, *Accident Source Terms for Light-Water Nuclear Power Reactors*, was used in the LWR PEIS Data Report to support core-to-containment release fraction. Although NUREG-1465 has been questioned by the public, it represents the most recent guidance for release fractions. Public comment on this report is beyond the scope of this PEIS.

It is true that NUREG-1465 tends to support the use of low-volatile release fractions lower than those used in NUREG-1150 and closer to the ones used by industry. This is not a coincidence, since the industry played a large role in revising NUREG-1465 to their liking. As described below, a careful look at the history of NUREG-1465, its supporting documentation and its domain of applicability indicates that the low-volatile release fractions it recommends are not sufficiently conservative for use in accident analysis of Ex-LWRs. It is therefore not relevant to the use of MOX in Ex-LWRs and should not be referenced in the DPEIS in this context. (A separate question is whether it has any validity at all).

The release behavior of the low-volatile radionuclides to containment from the molten reactor core during a severe accident is highly complex and dependent on details of accident progression that are not well understood; consequently, predictions of low-volatile release fractions are characterized by uncertainties spanning at least four orders of magnitude.[14] This uncertainty has been exploited by the nuclear industry, which consistently chooses the lower bound of the range in its own assessments.

64/09.09.08 cont.

NRC originally issued a draft of NUREG-1465 in which the low-volatile release fractions were similar to those used in NUREG-1150, e.g. on the order of 2-3%. These values were strongly disputed by industry, which preferred release fractions hundreds of times lower, such as those proposed by EPRI (the Electric Power Research Institute) for use in assessments of Ev-LWRs.

Rather than try to establish a rational and conservative basis for source term estimation, NRC submitted to industry pressure and lowered the NUREG-1465 low-volatile release fractions by a factor of approximately 50. Was this change warranted? Not according to the Advisory Committee on Reactor Safeguards (ACRS), which wrote that "these adjustments need to be better justified or not be made."[15] However, the ACRS' recommendation was ignored.

Industry comments on the draft of NUREG-1465 consisted of two main arguments as to why they believed its low-volatile release fractions were too high.[16] First, they alluded to recent research that "demonstrated" that low-volatile release fractions from melted fuel were indeed much smaller than those assumed in NUREG-1150. Second, they argued that the use of mean values of release fraction data was not appropriate for the low-

[14] H. Nourbakhsh, "Estimation of Radionuclide Release Characteristics Into Containment Under Severe Accident Conditions," U.S. Nuclear Regulatory Commission, NUREG/CR-5747, Nov. 1993.

[15] US NRC Advisory Committee on Reactor Safeguards, letter to NRC Chairman Ivan Selin, September 20, 1994.

[16] U.S. Nuclear Regulatory Commission, "Proposed Issuance of Final NUREG-1465," SECY-94-300, December 15, 1994.

volatile radionuclides, because the uncertainty distributions range over many orders of magnitude. In distributions of this type, the mean is unduly influenced by values at the extreme upper end of the range. The EPRI low-volatile release fractions were based on the median of the distribution, which was typically two to three orders of magnitude below the mean.

The evidence supporting the industry position was summarized in a document prepared for DOE's Advanced Light Water Reactor (ALWR) Program by a consulting firm, Los Alamos Technical Associates (LATA).[17] This report, which appears to have been accepted uncritically by NRC, is fundamentally flawed in at least one major respect and draws conclusions which are inconsistent with other NRC documents. The LATA report refers to a few experiments which observed small low-volatile release fractions, but notably omits discussion of one experiment in particular, the ST test series at the Annular Core Research Reactor (ACRR) at Sandia National Laboratories.[18] The ST test series were noteworthy for their observation of unexpectedly high release fractions for low-volatile elements, such as europium (RF = 6.4%).

The LATA report referred to the ST series in passing, without describing their results, but dismisses them as irrelevant because they were conducted in a reducing atmosphere, which he contends "represents a special case that may exist only locally for brief periods of time in an accident." It neglected to mention that the ST series was conducted explicitly to evaluate the impact of a reducing atmosphere on fission product release, an environment which was not adequately represented in the existing database. This information was necessary, according to the authors of the ST-1 report, because "there are ... regions of actual reactor cores that are expected to be in atmospheres of nearly pure hydrogen during severe accidents."[19]

In fact, one of the major sources of uncertainty in charting the progression of reactor accidents is the temporal and spatial variation in oxidation potential that may occur in a particular sequence. The ST series of experiments demonstrate that these uncertainties are closely related to uncertainties in low-volatile release fractions. This point, although undoubtedly known to NRC staff, does not seem to have been taken into account when uncritically revising downward the NUREG-1465 release fractions according to the erroneous industry contention that "all" recent data support such a revision.

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[17] D. Osetek, "Low Volatile Fission Product Release During Severe Reactor Accidents," Los Alamos Technical Associates, Inc, Albuquerque, NM, prepared for the U.S. DOE Idaho Operations Office,DOE/ID-13177-2, October 1992.

[18] M. Allen *et al.* "Fission Product Release and Fuel Behavior of Irradiated Light Water Reactor Fuel Under Severe Accident Conditions: The ACRR ST-1 Experiment," NUREG/CR-5345, Sandia National Laboratories, November 1991.

[19] *Ibid.*

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL

The question of oxidation potential is especially important with regard to americium. The volatility of metallic americium is greater by several orders of magnitude than that of the oxide, whereas for the other actinides the difference between metal and oxide volatility is not as great.

A major uncertainty in prediction of the release fraction of low-volatile radionuclides is associated with the vulnerability of Ex-LWRs to a class of accidents known as high-pressure melt expulsion (HPME) events. These are events in which the reactor vessel fails at high pressure leading to ejection of the molten core into the containment at high velocity and significant aerosol formation. HPME provides a mechanism by which relatively large fractions of low-volatiles can be converted to aerosol form in the containment atmosphere and therefore be subject to release into the environment. They should be distinguished from events in which the bulk of the core remains essentially intact throughout the meltdown.

According to NRC, the mean values of low-volatile release fraction uncertainty distributions into containment associated with HPME events in PWRs can be as high as 7%. One should note that the median values of these distributions are only about one order of magnitude less than the mean values, as opposed to the distributions of low-volatile in-vessel release fractions, in which the median is two to three orders of magnitude below the mean. Thus the industry argument that the mean values of low-volatile release fraction distributions do not accurately characterize the distributions does not apply to the HPME case.

HPME is of particular concern because of its relationship to another phenomenon known as Direct Containment Heating (DCH), in which the high heat transfer rates from the fuel aerosol causes a rapid rise in containment temperature that could lead to containment overpressurization and failure. HPME events, which are associated with both large low-volatile releases to containment and large probabilities of containment failure, can therefore result in large releases of low-volatiles to the environment as well.

These effects underscore the point that realistic source terms can only be generated by thorough analysis of specific accident sequences. NUREG-1465 provides representative release fractions for generic loss-of-containment accidents. As other NRC documents have pointed out, for radionuclides with release fractions spanning several orders of magnitude, such as the low-volatile species, neither the mean nor any other single measure contains enough information to accurately characterize the distribution. Knowledge of the actual details of the distribution is required to assess the likelihood of significant low-volatile releases in a particular accident sequence for a particular plant. Generic conclusions, such as those which appear in the DPEIS, are completely meaningless.

Given that large uncertainties in the prediction of low-volatile release fractions still exist, how significant is this issue on the actual consequences of a severe accident involving a MOX-fueled Ex-LWR? According to the DPEIS, it is not significant at all, because 60/09.09.08 cont.

"other radioisotopes that are released in an accident have more serious impacts on human health than the Pu used in the MOX fuel."[20] However, not only is this statement an oversimplification (e.g. the increase in transplutonium actinides is ignored), but it is also wrong. Because of the relative radiotoxicity and longevity of some of the actinides, they can have significant impacts on accident consequences. According to a study done at Sandia, which used the MACCS code to evaluate the relative importance of different radionuclides to the public health consequences of a severe LWR accident, it was found that the curium isotopes in particular were highly significant both for early and long-term exposures.[21] While the results obtained in that paper depend on the specific assumptions used in their model, they are useful to obtain a qualitative understanding of the importance of curium and the other actinides. 60/09.09.08 cont.

For instance, according to the results of the Sandia study, the ratio of the contribution of curium to cesium with respect to the total number of latent cancers resulting from an accident would be about 0.1, assuming Chernobyl release fractions of 0.4 for Cs and 0.035 for Cm, and core inventories characteristic of a LEU-fueled LWR. For a MOX-fueled LWR, the Cs inventory remains essentially the same, while the Cm inventory increases by a factor of approximately 4. This implies that the number of latent cancers due to the Cm release from a W-Pu MOX-fueled LWR would be about 40% of those due to Cs release. For plutonium isotopes, a similar calculation shows that the approximately three-fold increase in Pu release from a MOX-fueled reactor would result in a number of latent cancers about 80% of those due to Cs release. On the other hand, the decrease in Np would only translate into a few-percent decrease in the number of latent cancers. Because Cs release is the major contributor to latent cancers following an LEU-fueled LWR accident (typically 60% or greater), the Sandia result implies that the increased Cm and Pu releases from a severe accident affecting a W-Pu MOX-fueled LWR could result in a 50% increase in the total number of latent cancers as compared to an LEU-fueled LWR. (For R-Pu MOX, the increase would be significantly larger).

ii) Beyond design-basis accident probabilities

The DPEIS asserts that the substitution of MOX for LEU in LWRs would have no effect on the spectrum of accident probabilities. The document provides no evidence of this, nor does it even discuss a single safety-related issue associated with MOX use. Instead, it again refers the reader to vendor studies, which claim to demonstrate "substantial margins against limiting conditions" for transients involving MOX cores. 60/09.09.08 cont.

However, the situation is not nearly as straightforward as the DPEIS suggests.

[20] DPEIS, Vol. 2, Sect. 4.3.5.2.9. pg. 4-690.

[21] D. Alpert, D. Chanin and L. Ritchie, "Relative Importance of Individual Elements to Reactor Accident Consequences Assuming Equal Release Fractions," NUREG/CH-4467 (SANDIA85-2575), Sandia National Laboratories, Albuquerque, March 1986.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 42 OF 47

There are significant outstanding safety issues associated with the utilization of MOX in LWRs, even with partial-core, reactor-grade MOX, which is the only case for which there is industrial-scale experience. In the case of full-core, weapons-grade MOX, for which there is no industrial experience, numerous additional technical uncertainties with serious implications for safety would arise. 60/09.09.08 cont.

GESMO, the Generic Environmental Impact Statement on the Use of Mixed-Oxide Fuel in Light-Water Reactors, contained a brief discussion of some of the safety issues associated with partial-core, reactor-grade MOX. However, the document is completely out-of-date and many of the reassuring predictions it made concerning the viability of MOX have not been borne out in practice. For instance GESMO claimed that the issues of plutonium segregation and greater fission gas release in MOX fuel would not be significant; however, today they are major stumbling blocks for the qualification of MOX fuel for high burnups. The increased fission gas release from MOX fuel elements has led the French safety authority, DSIN, to limit burnups of MOX fuel in PWRs to 33 MWd/kgHM, well below that now achieved with LEU fuel, which imposes an economic penalty on the use of MOX in France.[22] 65/06.01.08

The DPEIS must include, at a bare minimum, a discussion of these issues at the same level of detail as GESMO, fully updated and with a candid discussion of the remaining uncertainties associated with MOX use in LWRs in the context of W-Pu disposition.

Relative to an LEU core, a MOX core is characterized by the following features: more negative moderator temperature and void coefficients, smaller delayed neutron fraction and prompt neutron lifetime, reduced control rod worth and greater inhomogeneities in fuel microstructure. Each one of these changes separately can have an adverse effect on safety. In addition, one can posit scenarios in which these changes interact synergistically to greatly amplify their individual effects.

The overall deleterious interaction between these elements can be understood in the following way. The decrease in reactor period associated with the smaller delayed neutron fraction and prompt neutron lifetime is perhaps the most serious issue, since this can result in a significant reduction in the time available for an operator to respond to transients. Because of the relatively small percentage of Pu-241 it contains (which has a larger delayed neutron fraction than Pu-239 and Pu-240), this problem is more severe for weapons-grade plutonium than for reactor-grade, especially at the beginning of cycle, when there is a nearly three-fold reduction in delayed neutron fraction.

For transients associated with an increase in coolant temperature (undercooling transients), such as those initiated by the loss-of-heatsink accident (LOHA) in PWRs, this

[22] A. MacLachlan, "New French RIA Tests Suggest Better Resistance of High-Burnup Fuel," *Nuclear Fuel*, September 11,1995, p.1.

M-281

06 01 08 Comment Number 65

Fabrication and use of MOX fuel using reactor-grade Pu is a mature, industrial scale technology in Europe with at least three vendors actively fabricating MOX fuel. There are some differences introduced by the use of weapons-grade Pu, which DOE is addressing as part of an ongoing weapons-grade MOX fuel development program and fuel qualification program. As a part of this, DOE is consulting with the European fuel vendors to benefit from their experience. The fuel qualification program would include in-reactor irradiation of fuel pellets and assemblies. A commercial reactor used to disposition Pu would have to be licensed by the NRC. Part of this licensing process would include an extensive, independent review of safety and performance issues associated with the use of MOX fuel.

In addition to issues associated with using MOX fuel versus LEU fuel, there are uncertainties in the different reactor types (BWR versus pressurized water reactor [PWR]), reactor vendors (Westinghouse versus Combustion Engineering), and reactor sites. In addition to reactor type, reactor vendor, and reactor sites, there are reactor-specific variations in the number of cooling loops, the emergency core cooling system, the type of control rods, reactor vessel neutron and thermal history, and the type of fuel loading pattern (for example, low leakage). A reactor-specific safety analysis will be done to determine the effects on the neutronic and mechanical characteristics of the reactor system, as well as the effects of reactor-specific characteristics on the accident analysis including pressurized thermal shock, loss of heat sink, and other accidents. The effects of extended burnup of the fuel will also be evaluated to determine the safety margin including the departure of nucleate boiling (DNB) ratio and other parameters over the life of the fuel assemblies.

decrease in stability may be compensated for by the greater negative temperature feedback associated with the greater magnitude of the moderator temperature coefficient.

However, because of the greater magnitude of the moderator temperature coefficient, the increase in core reactivity associated with a decrease in coolant temperature or increase in coolant density (overcooling or overpressure transients) will be more rapid for a MOX core than for an LEU core. In these events, the change in feedback behavior of a MOX core will aggravate, rather than compensate for, the reduced reactor period, so that the severity of overcooling/overpressure transients will increase. The reduced worth of control rods and soluble poisons also increases the risk that the transient will proceed without scram.

The third coupled safety issue is the intrinsic inhomogeneity of MOX fuel compared to LEU. Current methods of MOX fabrication, such as the MIMAS process in use at the MELOX plant in France, produce inhomogeneities in the fuel that lead to macroscopic clumping of plutonium at the periphery of the fuel rod during irradiation.[23] 66/06.01.08

This clumping phenomenon, which is very difficult to model accurately, can lead to formation of "hot spots" which can alter predictions concerning the local cladding temperature increase during reactivity insertions, such as overpressure transients in BWRs, and calculation of the departure from nucleate boiling (DNB) ratio. Additional uncertainties result from the lack of fabrication and irradiation experience with MOX fuel containing integral burnable absorbers (such as gadolinium), which would be required in MOX fuel for U.S. Ex-LWRs. The effect of gadolinium addition on the microstructure of MOX fuel both before and during irradiation is not known.

At least one of the vendor documents (the only one we have reviewed) cited indirectly by the DPEIS does not appear to address the issue of determining MOX-specific DNB ratios.[24] This renders its conclusions regarding the acceptability of MOX core response during transients untrustworthy. This point is underscored by the fact that the DPEIS, as well as the vendor references, assume that MOX fuel burnups will be significantly higher (e.g. 43 MWd/kgHM for PWRs) than those currently allowed in France. 65/06.01.08 cont.

The magnitude of the increase of overall risk of core damage and catastrophic release if MOX is substituted for LEU in an Ex-LWR is highly plant-specific, as is the relative contribution of various initiating events to core damage in LWRs. In order to get a sense of the issues involved is instructive to look at a few specific cases.

[23] A. MacLachlan, "French Working to Improve MOX Performance and Economics," *Nuclear Fuel*, November 6, 1995, p. 8.

[24] GE Nuclear Energy, "Study of Plutonium Disposition Using Existing GE Advanced Boiling Water Reactors," NEDO-32361, June 1, 1994.

06 01 08 Comment Number 66

Comment noted. Extensive irradiation experience, including both test and commercial irradiation, has shown that the process described by the commentor produces adequate homogeneity.

The commentor's reference #23 from the November 6, 1995, *Nuclear Fuel* more accurately refers to microscopic Pu-rich regions present throughout the fuel matrix. The inhomogeneities are microscopic, and are much smaller than those that have been shown acceptable through Reactivity Insertion Accident (RIA) testing.

The accepted values for Pu particle size based on RIA testing are supported by M.D. Freshley, E.A. Aitken, D.C. Wadekamper, R.L. Johnson, and W.G. Lussie in *Nuclear Technology* 15(1972) 239 and by T. Abe, N. Nakae, K. Kodato, M. Matsumoto, and T. Inabe in *J. Nuclear Materials* 188(1992) 154.

PWRs: Perhaps the most troubling consequence of the use of MOX in PWRs is the fact that one of the classes of events which are more severe for MOX cores than LEU cores, the overcooling transients, is also the same class which has the potential to cause one of the most dangerous and poorly understood safety phenomena associated with PWR operation, pressurized thermal shock (PTS) failure of the reactor pressure vessel (RPV).[25]

PTS is a phenomenon in which the reactor vessel can undergo catastrophic failure if the vessel remains pressurized during (or repressurizes immediately following) a sudden and significant drop in reactor temperature. In the worst case, this event, can result in a simultaneous failure of all the barriers (the fuel cladding, the RPV itself, and the containment building) to release of radionuclides into the environment.[26] Early containment failure can occur as a result of missile attack from fragments of the exploding RPV or from direct containment heating (DCH) in accident sequences in which partial melting of the fuel occurs prior to RPV failure. Such events are also associated with significant releases of low-volatile radionuclides to the environment, as discussed in the previous section; thus the substitution of MOX for LEU in Ex-LWRs can result in an increase in both the probability and the consequences of this class of accidents. 65/06.01.08 cont.

PTS transients can result directly from a large variety of initiating events, including main steam line breaks, small-break LOCAs (e.g. Three Mile Island) and steam generator tube ruptures (SGTRs).[27] Other events, such as instrumentation malfunctions or turbine trip due to loss of offsite power (LOOP), can initiate sequences resulting in PTS as well.[28] In many of these sequences, the time available for initiation of operator action is an important parameter.[29] Since the reduced response time to overcooling transients associated with the substitution of MOX for LEU increases the risk of inadequate or incorrect operator action, the risk that one of these initiating events will progress to PTS increases as well.

The susceptibility of a reactor vessel to PTS increases with irradiation time as a result of fast neutron embrittlement of the reactor vessel; the PTS risk increases sharply with reactor age. The approach used by the NRC for limiting the risk of PTS in the aging fleet of U.S. PWRs has been to restrict the extent of RPV embrittlement permissible in operating reactors before plant-specific evaluation is required. This is done by comparing

[25] U.S. Nuclear Regulatory Commission, "Reactor Pressure Vessel Status Report," NUREG-1511, December 1994.

[26] J. Collier and L. Davies, "Second Marshall Report Gives Grounds for Confidence," *Nuclear Engineering International*, May 1982, p. 30.

[27] NRC, NUREG-1511, *op cit.*, p. 4-2.

[28] U.S. Nuclear Regulatory Commission, "Pressurized Thermal Shock," SECY-82-465, November 1982.

[29] *Ibid*, p. 6-3.

PTS "reference temperatures" for base metal and welds, which provide a rough measure of the PTS susceptibility of the RPV with respect to the spectrum of identified overcooling transients, to "screening criteria" defined by NRC. Because of the large uncertainties characterizing initiation and progression of the PTS phenomenon, however, the actual level of risk of core damage and radionuclide release corresponding to the screening criteria, which were set in 1982 and have remained unchanged, is unclear.[30]

The NRC concluded in 1994 that only two U.S. PWRs would exceed the PTS screening criteria before the end of operating life. However, since that time NRC has apparently lost confidence in the adequacy and completeness of data it has received from operators in support of their compliance with the PTS rule. Reasons for this include new indications of greater uncertainties in the chemical composition of welds than was previously assumed and greater sensitivity of PTS reference temperature to variability of weld composition. Also, accurate analysis of PTS risk is seriously impaired by gaps in the data supplied by operators that result from withholding of information based on proprietary considerations.[31]

Because of the large uncertainties associated with the PTS phenomenon, the baseline PTS risk of Ex-PWRs is very difficult to assess accurately. The spectrum of initiators includes events of relatively high probability, such as SGTRs (approximately 0.005 per reactor-year) and small steam line breaks (0.02 per reactor-year), which have consequences that depend strongly on operator intervention and therefore would be more likely to progress to PTS in MOX cores than in LEU cores. This suggests that the overall risk of PTS may be substantially greater in MOX cores. Therefore, the PTS screening criteria now in use are not appropriate for MOX cores and will have to be reevaluated. 60/09.09.08 cont.

BWRs: In BWRs, the PTS risk is believed to be considerably smaller than that in PWRs. However, there are BWR-specific safety issues associated with MOX use as well. Probabilistic risk assessments such as NUREG-1150 have shown that core damage in typical BWRs is dominated by station blackout events. In this category is the turbine trip without bypass event, a loss-of-heatsink accident (LOHA) associated with overpressure transients and void collapse. This is one of the most limiting transients that can affect a BWR, and it is also one which is more severe for a MOX core, as discussed above. Thus the overall risk of core damage in BWRs will increase if MOX is substituted for LEU. 64/09.09.08 cont.

[30] Comments of David Okrent on SECY-82-465, member of NRC Advisory Committee on Reactor Safeguards, October 14, 1982.

[31] U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, NRC Generic Letter 92-01, Revision 1, Supplement 1: Reactor Vessel Structural Integrity, May 19, 1995.

NUCLEAR CONTROL INSTITUTE, WASHINGTON, DC,
PAUL LEVENTHAL
PAGE 46 OF 47

iii) The role of economics in safety assessment

An accurate assessment of the PTS risk associated with MOX use in Ex-PWRs is also closely related to reactor-specific economic issues, which are not addressed in the DPEIS. For instance, the risk may be reduced by annealing the reactor vessel, a procedure that is not anticipated to be very costly (about $20 million) but which nonetheless has been resisted to date by the PWRs identified as being of greatest PTS risk, such as the Palisades plant in Michigan. If DOE decides that the PTS risk should be mitigated by annealing the RPVs of Ex-PWRs chosen for Pu disposition, both the cost and the associated worker radiation exposure will probably have to be borne by the disposition program.

The degradation of steam generators (SG) in PWRs raises a similar issue. Some of the utilities which have responded to DOE's solicitation of Expressions of Interest have offered the use of PWRs which are known to be operating with severely degraded steam generators (Kewaunee). The operator of Kewaunee has opposed steam generator replacement (at a cost of approximately $100 million) on economic grounds. However, given the large contribution of SGTR events to overcooling and PTS transients, it would be unwise to pursue MOX disposition in these reactors without SG replacements. Again, the cost would probably have to be charged to disposition, since plants like Kewaunee are determined not to replace their steam generators. Charging the occupational exposure of SG replacement, typically about 150 person-rem, would increase the total incremental occupational exposure associated with the Ex-LWR MOX option of 27.2 person-rem per reactor listed in the DPEIS (Vol. II, Table 4.3.5.2.9-2, p. 4-690) by a factor of greater than five. 67/07.01.00

Another area in which safety and economics interact concerns the allowable MOX fuel burnup. Utilities are going to expect to be compensated for MOX-related issues that impair the reactor performance. Restriction of MOX burnups to well below LEU burnups, as is the case now in France, will have economic consequences and affect the cost of the MOX option. The calculus that will be used to balance the safety issues associated with high MOX burnups and the economic penalty is not addressed in the DPEIS. 68/01.04.00

3. Conclusions

The DPEIS does not contain sufficient information to consistently compare the occupational and public health and safety impacts of the immobilization and MOX options. To correct this problem, the final version should include:

- A full evaluation of the incremental health and safety impacts of the can-in-canister (CIC) immobilization options, both for routine operation and for accident conditions.

- A full evaluation of the incremental health and safety accident impacts of the existing LWR and CANDU MOX option, taking into account the specific properties of full-core,

M-281

07 01 00 Comment Number 67

Comment noted. DOE is not proposing this mitigation at this stage. Should the Existing Reactor Alternative be selected in the ROD, and this mitigation be determined to be necessary, such costs and exposures will be evaluated in subsequent tiered NEPA analyses, and cost studies as appropriate.

The costs for operating life extensions (for example, steam generator replacements) would be borne by the reactor owner. Such actions would likely require their license review and related environmental analysis. Contract negotiations for the utilization of the MOX fuel for Pu disposition would be competitive between reactor owners, and DOE and would consider related technical, cost, and environmental issues.

01 04 00 Comment Number 68

Comment noted.

weapons-grade MOX fuel and potential differences in the probabilities and consequences of accidents relative to LEU fuel. as well as specific issues (e.g. pressure vessel embrittlement) pertaining to the physical condition and operating history of existing reactors which are candidates for the program.

- A revision of the accident impact analysis of the evolutionary LWR option, taking into account the specifics of MOX fuel as described above, and using a more realistic source term for loss-of-containment accidents.

In all parts of the analysis, outstanding uncertainties should be clearly identified and their magnitudes estimated.