GENERAL ATOMICS, SAN DIEGO, CA, A. J. NEYLAN PAGE 1 OF 39

GENERAL ATOMICS

GA/DOE-027-96
Project 9866
April 30, 1996

Mr. Gregory P. Rudy, Acting Director
Office of Fissile Materials Disposition
U.S. Department of Energy
P.O. Box 23786
Washington, DC 20026-3786

SUBJECT: Comments on Draft Programmatic Environmental Impact Statement (EIS) on Storage and Disposition of Weapons-Useable Fissile Materials

References: (1) R.M. Forssell letter to Howard R. Canter, "Scope for Environmental Impact Statement for Long-Term Storage and Disposition of Weapons-Useable Fissile Material: Plutonium Consumption Modular Helium Reactor," GA/DOE-035-95, February 10, 1995

(2) A.J. Neylan letter to Howard R. Canter, "Programmatic EIS Screening Results," GA/DOE-068-95, June 6, 1995

Dear Mr. Rudy,

This letter provides the comments of General Atomics (GA) on the subject Draft Programmatic EIS. GA has previously provided to DOE via References (1) and (2) its comments on the results of the Screening Process, by which DOE selected the alternatives to be considered in this Programmatic EIS, and on the scope of the Programmatic EIS. Copies of these references are attached to this letter (Attachments 1 and 2). GA requests that the comments in Attachments 1 and 2 be included in the public record as part of its comments on the Draft Programmatic EIS itself. The comments primarily addressed 1) DOE's decision and rationale for not including the Gas Turbine Modular Helium Reactor (GT-MHR) as a reasonable alternative to be considered in this Programmatic EIS and 2) DOE's interpretation of the spent fuel standard as an objective that is not to be exceeded (by eliminating from consideration in this Programmatic EIS all alternatives capable of exceeding the spent fuel standard), without having provided the public with a full comparison of the environmental impacts associated with that decision.

Additional comments are provided with this letter in Attachment 3. These comments address 1) the manner in which DOE has provided only superficial consideration (in a three page appendix to the Programmatic EIS) of multipurpose reactor options for plutonium disposition and tritium supply; 2) the imposed schedule for demonstration of disposition technologies and for completion of disposition and the environmental impacts that result from that schedule; 3) the suitability of final waste forms for permanent disposal in terms of long term safeguards requirements and long term radionuclide containment; 4) issues associated with borosilicate glass as a vitrification option; 5) the viability of using electrometallurgical treatment (pyroprocessing) as an immobilization option; 6) use of a coated particle waste form for plutonium

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M-132

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 2 OF 39

Mr. Gregory P. Rudy -2- GA/DOE-027-96

immobilization; and 7) the treatment of certain environmental impacts associated with the CANDU reactor option for plutonium disposition.

GA continues to believe that the GT-MHR (identified as the Plutonium Consumption Modular Helium Reactor [PC-MHR] when applied to the plutonium disposition mission) must be evaluated in the Programmatic EIS because it is a reasonable alternative for plutonium disposition. GA also believes that the manner in which DOE has applied the spent fuel standard is a significant issue that must also be evaluated in the Programmatic EIS, especially in view of the availability of reasonable alternatives such as the GT-MHR, which is capable of exceeding the spent fuel standard and leaving a factor of five less plutonium-239 remaining than reactor alternatives that merely meet the standard. 1/14.00.00 2/01.05.00

The National Environmental Policy Act (NEPA) requires that all reasonable alternatives and significant issues be evaluated in the PEIS process. By addressing all reasonable alternatives and significant issues as required, DOE will provide a strong foundation for the Record of Decision, will avoid the potential for substantial delays in the plutonium disposition effort that might result from legal action as a result of the manner in which DOE has discharged its obligations under NEPA, and will enhance the credibility of DOE's efforts in the eyes of all stakeholders who have an interest in the resolution of the plutonium disposition problem.

GA again respectfully requests that DOE reconsider its decision to exclude the GT-MHR and the interpretation of the spent fuel standard from consideration in the Programmatic EIS. If you have any questions regarding General Atomics' comments or would like further information, please contact Dave Alberstein at (619) 455-2088.

Sincerely,

D. Alberstein for AJN

A.J. Neylan
Vice President, Power Reactor Group

AJN/DA:da

Attachments:

1) GA/DOE-035-95, February 10, 1995
2) GA/DOE-068-95, June 6, 1995
3) Additional General Atomics Comments on the Draft Programmatic Environmental Impact Statement for Storage and Disposition of Weapons-Useable Fissile Materials

cc:

J.D. Nulton, DOE-HQ

M-132

14 00 00 Comment Number 1

The Advanced Deep Burn Reactors Option, including Modular Helium Reactors (MHR), was considered in the screening process. Notwithstanding the many potential benefits of their use, the technical immaturity would call for costly and lengthy development and demonstration efforts to bring them to a viable status. The Screening Committee decided that the increased Pu burn-up offered by this option would not counterbalance its cost, schedule, or technical risks, and therefore eliminated this option from further consideration. Clarification has been provided in Appendix N of the Final PEIS for the various multipurpose reactor concepts.

01 05 00 Comment Number 2

The Department of Energy, in considering the Spent Fuel Standard, did evaluate the adequacy of the Standard versus the greater degree of destruction achievable with other options such as the Deep Burn Reactor and the Accelerator Options in the Screening Report. It was judged that the Spent Fuel Standard is adequate since it would convert the weapons Pu to a form that would make it as difficult to retrieve and reuse in a weapon as the Pu contained in the much larger existing volume of spent fuel from commercial nuclear reactors.

The Department of Energy concluded that the shorter disposition time achievable with more mature technologies was more desirable than the greater Pu destruction that could only be achieved over a much longer time period through the use of Deep Burn Reactors and Accelerators. The NAS also adopted the Spent Fuel Standard as the most acceptable form for conversion of weapons Pu.

ATTACHMENT 1 TO GA/DOE-027-96

GA/DOE-035-95
February 10, 1995

M-132

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 4 OF 39

GENERAL ATOMICS

GA/DOE-035-95
Project 6301
WBS: 5109.91
February 10, 1995

Mr. Howard R. Canter, Technical Director
Office of Fissile Materials Disposition
U.S. Department of Energy
Washington, DC 20585

SUBJECT: Scope for Programmatic Environmental Impact Statement for Long-Term Storage and Disposition of Weapons-Useable Fissile Material: Plutonium Consumption Modular Helium Reactor

Dear Mr. Canter:

Thank you for the opportunity to meet with you on February 1, 1995, to discuss the status of the Plutonium Consumption Modular Helium Reactor (PC-MHR) in the scoping process for the Programmatic Environmental Impact Statement (PEIS) for Long-Term Storage and Disposition of Weapons-Useable Fissile Materials. During that meeting you did not indicate that the PC-MHR had been eliminated in the screening process for the PEIS. However, we note from the draft report to Congress on the multipurpose reactor, which is dated January 31, 1995, and which GA received from your office for review and comment on February 3, 1995, that the PC-MHR has been eliminated from consideration.

GA will provide its comments on the draft multipurpose report, per your request, via a separate letter. The purpose of this letter is to explain why GA believes that it would be improper to exclude the PC-MHR as an alternative in the PEIS for fissile materials disposition and to request that DOE reconsider its decision to exclude the PC-MHR from evaluation in the PEIS. GA is sufficiently concerned about this matter that it has sought the advice of consultants with expertise in the legal requirements of the National Environmental Policy Act (NEPA). We are advised that our concerns are substantive and have merit relative to the requirements of NEPA.

GA believes that under both the letter and the spirit of NEPA the PC-MHR must be included and evaluated in the PEIS. NEPA regulations require that the PEIS evaluate all reasonable alternatives (40CFR1502.14) and provide in depth analysis of all significant issues (40CFR1501.7 and 40CFR1508.27). While NEPA itself does not provide a benchmark for what constitute "reasonable" alternatives, certain principles are clearly discernable from the applicable regulations and court decisions. While the scope of reasonable alternatives must, of course, be bounded by some sense of feasibility or practicality, it is not permissible to exclude any viable alternatives merely on, for example, policy or political grounds. 3/08.00.00

The PC-MHR is a reasonable alternative for plutonium disposition relative to DOE's nine published screening criteria. Among the alternatives that involve construction of a new reactor dedicated to the plutonium disposition mission, it has superior safety and environmental impact characteristics, very low life cycle cost under government ownership (even when remaining engineering development costs are taken into account), a fuel cycle with superior diversion and proliferation resistance characteristics, and a spent fuel form that is best suited for long term disposal in a geologic repository. The strong interest 4/14.00.00

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M-132

08 00 00 Comment Number 3

The MHRs were considered as Reactor Alternatives in the screening process. The MHRs were not excluded on political grounds. The Screening Committee decided that the increased Pu burn up offered by this option would not counterbalance its cost, schedule, or technical risks, and therefore eliminated this option from further consideration. Clarification has been provided in Appendix N of the Final PEIS for the various multipurpose reactor concepts.

14 00 00 Comment Number 4

To meet the Nation's goals in support of its nonproliferation policies, DOE determined that the "clear and present danger" demands that the disposition of Pu be initiated within approximately a decade. To achieve this objective, an alternative must be nearly ready for development or be an extension of an existing technology. Clarification has been provided in Appendix N of the Final PEIS for the various multipurpose reactor concepts.

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 5 OF 39

expressed by the Russians in using the MHR for plutonium disposition is clear evidence of its ability to influence disposition of international weapons-useable materials inventories and to foster cooperation with Russia. 4/14.00.00 cont.

With regard to DOE's timeliness criterion, under the requirements of NEPA DOE cannot exclude reasonable alternatives on the basis of administrative deadlines or artificial time schedules. It should be noted that regardless of the alternative chosen for plutonium disposition, construction and use of facilities for long term storage of surplus weapons grade plutonium will be necessary. Although the projected schedule for initial deployment of the PC-MHR in the United States is about five years longer than that claimed during Phase I of the DOE Plutonium Disposition Study (PDS) by proponents of other reactor alternatives, the critical factor is that the PC-MHR is capable of completing the plutonium disposition mission within the 25 year overall mission duration that has served as the planning basis for the PDS. 5/07.00.00

The draft report to Congress on the multipurpose reactor basically states that the PC-MHR is being eliminated on the basis of "technical immaturity". This statement is inconsistent with the fact that the MHR has been developed based upon extensive experience with more than 50 gas-cooled reactors built and operated over the last 35 years, including five high temperature gas-cooled reactors that have confirmed the major design features of the MHR.

This statement is also incongruous with previous positions taken by DOE. Only three years ago the MHR was one of the final alternatives under consideration for selection as the New Production Reactor. It was, by most accounts, the most likely alternative to have been selected had that Record of Decision not been postponed only one month prior to its scheduled release date. The MHR had been selected as one of the final alternatives following extensive review by the Secretary's Energy Research Advisory Board. In light of this history, it is unjustifiable that DOE would not evaluate in the PEIS for fissile materials disposition a technology option that so recently was under favorable consideration for a mission that is vital to national security. These facts alone demonstrate that the PC-MHR must be included as a reasonable alternative in the PEIS. 6/01.05.00

The PC-MHR differs from the new production reactor design in only two ways: use of plutonium oxide fuel and use of the direct cycle gas turbine to improve plant efficiency and economics. As indicated by the enclosed white paper on fuel development status, which summarizes information that DOE has had in its possession for almost two years under the Plutonium Disposition Study, coated particle plutonium fuel that meets the performance requirements of the PC-MHR has been successfully demonstrated in six separate irradiation tests in a high temperature gas-cooled reactor environment. These tests confirmed the ability of weapons grade plutonium coated particle fuel to achieve high levels of plutonium destruction while maintaining coating integrity and retention of radionuclides in the fuel particles. 7/14.00.00

As indicated by the enclosed white paper on the power conversion system, there exists an extensive technology base for the power conversion system major components. Basic research and development are not needed to complete engineering and demonstration of the system. As shown in GA's Phase II Plutonium Disposition Study report, the power conversion system is not on the critical path for deployment of the PC-MHR. The power conversion system of the MHR has been assessed by two organizations recognized throughout the world as experts in gas turbine and Brayton cycle technology - General Electric and AlliedSignal. Both have endorsed the power conversion system and have concluded that it can be demonstrated in a timely manner.

M-132

07 00 00 Comment Number 5

During the PEIS scoping process and related public meetings, DOE asked for input on the screening criteria. Some respondents reacted to the timeliness statement that "The technology concept should be demonstrated within approximately 20 years and disposition should be completed within approximately 50 years." These respondents ranked our stated definition of timeliness low indicating that 20 and 50 years was too long and it was important for DOE to start and finish earlier. Clarification has been provided in Appendix N of the Final PEIS for the various multipurpose reactor concepts.

01 05 00 Comment Number 6

The Department of Energy recognizes the potential benefits (unrelated to Pu disposition) that can be offered by the Plutonium Consumption Modular Helium Reactor (PC-MHR) Option. Nevertheless, as explained in Appendix N of the Final PEIS, because this technology needs further development and the benefits do not counterbalance the cost, schedule, or technical risks associated with this option, there is no justification to develop this technology solely for the purpose of Pu disposition. Pu disposition can be accomplished using existing technologies to achieve the Spent Fuel Standard. It is unnecessary to exceed the Spent Fuel Standard since the amount of Pu that could be declared surplus from weapons is much less than the inventory of Pu in commercial spent fuel.

14 00 00 Comment Number 7

The Advanced Deep Burn Reactors Option, including MHRs, was considered in the screening process. Notwithstanding the many potential benefits of their use, the technical immaturity would call for costly and lengthy development and demonstration efforts to bring them to a viable status. The Screening Committee decided that the increased Pu burn-up offered by this option would counterbalance its cost, schedule, or technical risks; therefore, this option was eliminated from further consideration. Appendix N of the Final PEIS provides further explanation related to the various multipurpose reactors.

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 6 OF 39

Mr. Howard R. Canter - 3 - GA/DOE-035-95

Based upon these considerations, GA believes that there is no rational argument, relative to DOE's nine published criteria for the screening of disposition alternatives or to DOE's stated purpose and need for taking action, upon which the PC-MHR can be eliminated from consideration and evaluation in the PEIS. GA is aware that DOE has eliminated some plutonium disposition alternatives based on the assessment that their deployment would be in violation of certain international treaties or other legal considerations. GA is aware, however, of no such institutional considerations that justify elimination of the PC-MHR from evaluation in the PEIS. 8/01.00.00

In addition to GA's concerns regarding the improper exclusion of the PC-MHR from evaluation in the PEIS, there is an additional significant issue which must be addressed in the PEIS. GA believes that the PEIS must consider the adequacy and acceptability of the spent fuel standard. In addition to its many advantages cited above, the PC-MHR is capable of exceeding the spent fuel standard in a single pass of the fuel through the reactor without recycle. The final product resulting from the disposition of weapons grade plutonium in the PC-MHR contains a factor of five less plutonium-239 than that which results from disposition in other reactor options that merely meet the spent fuel standard. If the PC-MHR and other reasonable "deep burn" alternatives are eliminated from evaluation at this time, such elimination will constitute a de facto adoption of the spent fuel standard without the full evaluation required under NEPA. As noted in the National Academy of Sciences (NAS) report on plutonium disposition, "over the long term, however, steps beyond the spent fuel standard will be necessary." The PC-MHR has the capability to take those steps today and provide a one-step, permanent solution to the problem of disposition of surplus weapons grade plutonium with lower total environmental impact than that resulting from the choice of alternatives that merely meet the spent fuel standard and leave the matter of ultimate disposition, and its associated environmental impacts, for future generations. 2/01.05.00 cont.

During the public scoping meetings for the PEIS held in the summer and fall of 1994, the adequacy and acceptability of the spent fuel standard was a subject of much discussion and disagreement. These discussions are partially documented in DOE's PEIS Scoping Meeting Comment Summary Report of November 30, 1994. However, during its presentations in the public meetings on plutonium disposition on December 13-14, 1994, DOE appeared to dismiss this significant issue on the basis that there did not "appear to be strong sentiment for exceeding the spent fuel standard." Members of Congress have also indicated that a consensus has not been reached in Congress on the adequacy of the standard. Questions have been raised regarding whether the alternatives that merely meet the spent fuel standard will adequately meet one of the major national security objectives of the plutonium disposition effort identified in the NAS report and adopted by DOE in its June 21, 1994, Notice of Intent to prepare the PEIS: to minimize the risk that weapons or fissile materials could be reintroduced into the arsenals from which they came.

DOE appears to be adopting the spent fuel standard without providing to the public the results of an objective assessment of the diversion and proliferation resistance and total environmental impacts of alternatives that meet the standard vs reasonable alternatives for plutonium disposition that can exceed the spent fuel standard. The NAS report recommended that efforts to exceed the spent fuel standard not be addressed at this time based upon certain assumptions about deployment time, cost, and technical uncertainty of alternatives that can exceed the standard. These assumptions were not supported by NAS with any specific analyses. The DOE Plutonium Disposition Study later provided such analyses, and the results indicate that some of these assumptions are ill founded. 6/01.05.00 cont.

M-132

01 00 00 Comment Number 8

Comment noted. Appendix N has been revised to provide further explanation concerning the PC-MHR and other multipurpose reactors as alternatives for Pu disposition.

The adequacy of the spent fuel standard is, accordingly, a significant issue which must be evaluated in detail in the PEIS. However, regardless of whether the spent fuel standard is considered in the PEIS and ultimately deemed to be an acceptable interim standard, the PC-MHR is a reasonable alternative for plutonium disposition based on its superior safety and environmental characteristics, cost characteristics, diversion and proliferation resistance, spent fuel form, and level of technical maturity as evidenced by its earlier consideration under the New Production Reactor Program. The ability of the PC-MHR to exceed the spent fuel standard is a readily achievable additional benefit. 2/01.05.00 cont.

In summary, GA believes that the PC-MHR must be evaluated in the PEIS because it is a reasonable alternative for plutonium disposition. GA also believes that the adequacy and acceptability of the spent fuel standard is a significant open issue that must also be evaluated in the PEIS, especially in view of the availability of reasonable alternatives such as the PC-MHR, which is capable of exceeding the spent fuel standard and leaving a factor of five less plutonium-239 remaining than reactor alternatives that merely meet the standard. 1/14.00.00 cont. 2/01.05.00 cont.

NEPA requires that all reasonable alternatives and significant issues be evaluated in the PEIS process. By addressing all reasonable alternatives and significant issues as required, DOE will provide a strong foundation for the Record of Decision, will avoid the potential for substantial delays in the plutonium disposition effort that might result from questions regarding the manner in which DOE has discharged its obligations under NEPA, and will enhance the credibility of DOE's efforts in the eyes of all stakeholders who have an interest in the resolution of the plutonium disposition problem.

GA respectfully requests that DOE reconsider its decision to exclude the PC-MHR and the spent fuel standard from consideration in the Programmatic EIS. 1/14.00.00 cont.

Sincerely,

R. M. Forssell
Senior Vice President
Power Reactor Group

Enclosures:

1) Fuel Development Status of the Plutonium Consumption Modular Helium Reactor (PC-MHR)
2) GT-MHR Power Conversion System - State of the Art Technology

cc:
C.B. Curtis
R.W. DeGrasse
J.D. Nulton
A.I. Cygelman
J.M. Turner, DOE-OAK
S. El Safwany, DOE-OAK

M-132

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 8 OF 39

FUEL DEVELOPMENT STATUS OF THE
PLUTONIUM CONSUMPTION MODULAR HELIUM REACTOR (PC-MHR)

STATUS

Fuel that meets PC-MHR operating requirements has been demonstrated. Additional tests are planned to expand the data base and confirm performance under accident conditions.

BACKGROUND

The PC-MHR can achieve very high levels of weapons grade plutonium destruction without recycle. Destruction of more than 90% of the initially charged plutonium-239 and more than 65% of the initially charged total plutonium is obtained in a single pass through the reactor. This level of destruction makes the discharged plutonium in the spent fuel particularly unattractive for weapons applications relative to the plutonium contained in the spent fuel from other reactor types.

The PC-MHR can achieve this high level of plutonium destruction due, in large part, to the high burnup capability of its plutonium oxide, refractory coated particle fuel. The high burnup capability of this fuel, and its excellent retention of fission product radionuclides, have been demonstrated in irradiation tests of TRISO-coated plutonium fuel conducted in the late 1960s and early 1970s.

The PC-MHR design includes a high pressure, low leakage containment. By taking credit for the enhanced radionuclide retention provided by this containment, the allowable coated particle fuel failure during design basis accident conditions is about a factor of ten larger for the PC-MHR than for the commercial GT-MHR, which has a vented, low pressure containment.

The fuel quality and performance requirements of the PC-MHR during normal operation are similar to performance levels experienced at the Fort St. Vrain reactor, for which more than 30 metric tonnes of TRISO-coated uranium particle fuel were fabricated. This fuel met the required as-manufactured quality levels and, as evidenced by primary coolant radionuclide activity levels that were a factor of 30 less than the design basis, performed much better than required. The core average design basis performance requirement for PC-MHR fuel is a coating failure fraction of less than 4×10^{-4} at an average burnup of about 590,000 MWd/MT (785,000 MWd/MT peak).

Six irradiation tests have been conducted using near weapons grade, highly enriched (88% Pu-239) TRISO-coated plutonium fuel. Five of these tests were performed as part of the Dragon high temperature gas-cooled reactor project (United Kingdom) in the late 60s, and the sixth was performed by General Atomics in the Peach Bottom HTGR in the early 1970s. The fuel for the Dragon tests, which consisted of loose particles in graphite holders, was fabricated by Belgonucleaire in Europe. For the Peach Bottom test, Oak Ridge National Laboratory fabricated the coated particles and standard fuel rod compacts.

These six irradiation tests encompassed a range of irradiation temperatures up to 1450°C and peak fast neutron fluences of up to 2.3×10^{25} n/m^2. Burnups of up to 747,000 MWd/MT were achieved, which resulted in destruction of more than 90% of the initially charged plutonium-239. These irradiation conditions are, with the exception of fast neutron fluence, nearly the same or in excess of those required for the fuel in the PC-MHR. The plutonium fuel like that planned for use in the PC-MHR performed well in these tests, showing release of fission products at a rate that was about a factor of ten less than that required for fuel in the PC-MHR. Based on the results of simulated core heatup tests of other TRISO-coated particle fuels with a range of compositions and irradiation conditions, minimal additional failure of the plutonium fuel particles is expected under accident conditions in which the peak fuel temperature is expected to approach 1600°C.

The plutonium coated particle fuel irradiation test results are consistent with results obtained for other high burnup TRISO-coated fuels. High burnup, highly enriched fuel particles have been under development at General Atomics for more than twenty five years.

The reference fissile fuel particle for the large HTGR designs of the 1973-1982 period was 93.15% enriched uranium carbide featuring essentially the same TRISO coating planned for use in the PC-MHR. In 1978 General Atomics prepared

a safety analysis report on the use of this highly enriched uranium carbide fuel in Fort St. Vrain reload fuel elements. NRC approval for use of this fuel was provided in 1979, based on a review of the safety analysis report and of the irradiation data base for this high burnup fuel.

The irradiation test experience for this fuel at that time included 316,000 particles successfully tested at nominal temperatures from 885°C to 1240°C and fast neutron fluences of 3.5 to 12.0 x 10^{25} n/m^2. A total of 250,000 of these particles were irradiated to burnups of at least 662,000 MWd/MT, and approximately 9,000 particles were irradiated to nominal burnups of 704,000 MWd/MT, which corresponds to destruction of more than 90% of the initially charged uranium-235. Higher burnup levels were achieved in later tests.

NRC approval of use of this fuel in Fort St. Vrain reloads indicates that there is a substantial database that confirms the ability of TRISO-coated particle fuel to achieve high burnup and high levels of destruction of the initially charged fissile material. When these high burnup uranium fuel data are considered in combination with the plutonium fuel irradiation tests in the Dragon and Peach Bottom reactors, it is clear that TRISO-coated plutonium fuel particles can be manufactured to meet operational and safety requirements and to achieve the high levels of plutonium destruction of which the PC-MHR is capable. Table 1 shows a comparison of PC-MHR design conditions with the irradiation experience for high burnup plutonium and uranium TRISO-coated particle fuel.

It should be noted that recent (1990-92) unsuccessful irradiation experience with an experimental, modified fuel design (TRISO-P) for the DOE New Production Reactor and Commercial GT-MHR programs is not relevant to the status of plutonium fuel development. The TRISO-P coating was developed in an attempt to improve as-manufactured quality and inservice performance by about an order of magnitude over the requirements that would apply to PC-MHR fuel. Although the as-manufactured quality was improved, irradiation test results showed that the coating design and fabrication process changes actually resulted in worse inservice performance under irradiation than Fort St. Vrain fuel and previous fuel tests. This modified fuel design has been discarded, and existing prior technology is being utilized. TRISO-coated plutonium fuel for the PC-MHR will be based upon the successful experience obtained on high burnup, highly enriched fissile fuel during the last twenty five years.

Although the results of plutonium fuel irradiation tests obtained to date are positive and performance comparable to PC-MHR requirements was achieved at FSV, more plutonium fuel development work is planned to increase the level of confidence associated with these results and to strengthen the statistical significance of the data. Tests will be conducted on irradiated plutonium coated fuel particles to confirm their behavior under simulated core heatup accident conditions. In addition, the equipment and remote processes used to fabricate plutonium coated particle fuel will be adapted from those used to fabricate uranium fuel and will be qualified for use in a full scale production operation. Plans for these activities have been documented in a plutonium fuel development plan for the PC-MHR.

TABLE 1
COMPARISON OF PC-MHR FUEL OPERATING CONDITIONS
WITH HIGH BURNUP TRISO-COATED FUEL IRRADIATION EXPERIENCE

Parameter	PC-MHR Design Goals	Plutonium TRISO Irradiation Experience	Uranium TRISO Irradiation Experience
Peak Fuel Temperature, °C	1250 (1) 1600 (2)	1275 - 1450	900 - 1550 ~ 2000 (3)
Peak Fast Neutron Fluence, 10^{25} n/m^2 (E > 0.18 Mev)	4.2	2.3	12.0
Peak Burnup, MWd/MT	785,000 (590,000 Avg)	747,000	~750,000

(1) Normal Operating Conditions
(2) Design Basis Accident Conditions
(3) Post Irradiation Heatup Tests

M-132

GT-MHR Power Conversion System - State of the Art Technology

1. Summary

Extensive technology data bases exist for the major GT-MHR power conversion system (PCS) components, including the turbocompressor, bearings, generator, recuperator, and precooler/intercooler. Closed Brayton cycle gas turbine technology is well understood. Some 20 fossil-fired closed cycle gas turbine plants have operated for over one million hours with high reliability and availability.

Based on a highly recuperated and intercooled cycle, an efficiency of about 47% is realizable at a very modest level of turbine inlet temperature (~ 850°C) compared with contemporary open cycle gas turbines.

Experience gained in Germany with the operation of two large helium gas turbine systems (Oberhausen II 50MWe Helium Gas Turbine Plant, and the HHV Test facility) substantiates the claim that helium gas turbine power conversion systems are regarded as state-of-the-art. Within the U.S. there is strong industrial capability to facilitate the transfer of the necessary gas turbine enabling technology to make the GT-MHR a reality within the next ten years.

2. Design Methodology for GT-MHR Power Conversion System

The properties of helium reduce the size and geometrical complexity of the various power conversion components. Dynamic, thermal and structural design procedures, computer codes, and industry standards used are identical to conventional air-breathing gas turbine practices. The existing HTGR materials data base, established over a 3 decade period, involve materials testing in a helium environment by industry and the national laboratories, and is being fully utilized. Fabrication of the power conversion system components can be accomplished with existing techniques, machine tools and processes, and the size of the components is bounded by existing power generation equipment.

3. Turbocompressor

The largest industrial combustion gas turbine operating today is rated at 226 MWe, and units with outputs of over 300MWe are projected to be in utility service before the year 2000. The size of the 285MWe GT-MHR turbocompressor is physically smaller than the aforementioned combustion gas turbine, as a result of the use of helium (at high pressure) as the working fluid. The number of compressor and turbine stages is comparable with existing industrial gas turbines. Compressor and turbine designs are based on a combination of the following: 1) low Mach number, 2) high Reynolds number, 3) clean oxide-free blading surfaces in the closed helium circuit, and 4) close blade-tip clearance for the base-loaded plant (i.e. not subjected to rapid transients) resulting in high efficiency. The turbocompressor is being designed using the same methods, tools, and standards used for aerospace and industrial gas turbines. The performance of helium turbomachinery has been demonstrated in the Oberhausen plant and the HHV test facility.

The turbine inlet temperature of 850°C is about 400°C below that in the aforementioned large industrial gas turbines. This simplifies the turbine design in that un-cooled blades of conventional nickel-base alloys can be used. For the integrated PCS, circumferential static seals are necessary between the turbocompressor and other components and structures. The size of these seals and their operating environment (i.e. temperature and pressure differential) are bounded by existing power conversion systems.

4. Active Magnetic Bearings

The utilization of magnetic bearings has three major advantages: it 1) eliminates the possibility of lubricant ingress to the reactor circuit, 2) provides an on-line diagnostic system for monitoring the health of the rotating assembly, and 3) facilitates adjusting bearing performance on-line. Large vertical rotor systems (centrifuges) have operated successfully with magnetic bearings. While the rotor weight of the GT-MHR is heavier than in applications to date, the thrust bearing unit loadings and peripheral velocities are bounded by current operating experience.

A formidable magnetic bearing technology base exists: over 5500 units with over 8 million hours in operation, including over 160 large turbomachines (e.g. compressors, turboexpanders) with over 1.5 million hours of operation.

5. Generator

Vertical electrical machines are used in boiler feedwater pumps and hydroelectric plants, and only minor modifications to existing generators are necessary for the vertical orientation of the generator in the GT-MHR plant. While the dielectric strength of helium is different from that of air or hydrogen (used in the cooling of conventional generators), only minor modifications to the electrical insulation are necessary. For the AVR and THTR plants the circulators, embodying electric motor drives submerged in helium, performed trouble-free.

6. Recuperator

The use of a compact plate fin recuperator facilitates the installation of a high performance unit (i.e. 95% effectiveness, 2% pressure loss) within the confines of the PCS steel vessel. Existing recuperator technology established by AlliedSignal Aerospace is directly applicable to the GT-MHR. Over 60 recuperated industrial gas turbines (using this type of heat exchanger) have accumulated over 3 million hours of service. Units with 95% effectiveness have been demonstrated in service. The operating environment for these units, in terms of transients and thermal shock, is more severe than would be experienced in the GT-MHR.

Plate-fin heat exchangers are used extensively in the aerospace industry and Allied Signal has produced several million for aircraft systems. The GT-MHR recuperator will benefit from two air-breathing applications, 1) heavy duty industrial recuperators in terms of materials, fabrication, and high temperature service, and 2) aircraft/aerospace heat exchangers in terms of very compact high performance surface geometries.

7. Precooler/Intercooler

The precooler and intercooler are helium-to-water heat exchangers that operate in a very benign environment, with metal temperatures less than 250°F. The technology for the units is essentially commercially available. These units should not be compared with steam generators since the water side is pressurized only to suppress boiling,and stable operation is assured with single phase fluids on both sides of the unit. Since the helium pressure is greater than the water pressure, the issue of water ingress into the reactor circuit, as a result of a tube failure for example; is obviated. A faulted tube can be plugged at the tubesheet, which is external to the vessel and is accessible.

8. PCS Development and Testing

Based on the utilization of gas turbine and aerospace industry technology bases the PCS can be realized without the need for further basic R&D. Early in the program, data from subcomponent tests (e.g. bearings, seals) will be available for inclusion in the PCS final design.

A hallmark of the program will be the testing of the PCS in an integrated test facility. The turbomachine will be operated at full temperature and full speed. The comprehensive nature of the PCS testing program removes a major risk element, and will give designers a high degree of confidence that all of the PCS requirements will be met when the system is operated with a nuclear heat source.

9. Maintenance

While designed to last the 60 year plant life, the major PCS components have been engineered to facilitate ease of removal and replacement. The turbocompressor will be removed at 7 year intervals (for refurbishment), with a spare unit kept at the plant site. Experience gained from the AGR plants in the U.K. in terms of removal, replacement, and handling of large components (in shielded casks) is particularly germane.

ATTACHMENT 2 TO GA/DOE-027-96

GA/DOE-068-95
June 6, 1995

M-132

GENERAL ATOMICS

GA/DOE-068-95
Project 6301
WBS: 5109.51
June 6, 1995

Mr. Howard R. Canter, Technical Director
Office of Fissile Materials Disposition
U.S. Department of Energy
Washington, DC 20585

SUBJECT: Programmatic EIS Screening Results

Dear Mr. Canter:

General Atomics has received your letter of April 14, 1995, which presented DOE's rationale for excluding the Plutonium Consumption Modular Helium Reactor (PC-MHR) from consideration as a reasonable alternative for plutonium disposition in the Programmatic Environmental Impact Statement (PEIS) for Long Term Storage and Disposition of Surplus Fissile Material. GA has also reviewed the PEIS Implementation Plan and the Summary Report of the Screening Process. This letter provides GA's response to your letter and its comments on these documents.

GA has reviewed these documents in an effort to understand the factors that led DOE to reject the PC-MHR as unreasonable and lacking in technical maturity. This was DOE's conclusion even though the technology was, as recently as 1992, the leading candidate for new tritium production capacity and is still under consideration by DOE for the important mission of tritium production.

The summary screening report characterizes the various alternatives against the eleven screening criteria developed by DOE. GA believes that the criteria used were, in general, appropriate. However, DOE's assessment of the PC-MHR against the criteria is, in some cases, very difficult to understand. GA is concerned, based upon its review and upon information it has received from others, that the exclusion of the PC-MHR from consideration is more closely related to an apparent intention not to support the development of advanced reactors, including the gas-cooled reactor, than it is to any objective consideration of the capabilities of the PC-MHR relative to the screening criteria.

1/14.00.00 cont.

Attachment 1 provides GA's detailed comments on DOE's evaluation of the PC-MHR and proposed exclusion of the PC-MHR from consideration in the PEIS. The attachment addresses the assessment of the PC-MHR against the screening criteria, adoption of the spent fuel standard, and DOE's approach to multipurpose options for plutonium disposition and tritium production.

DOE has rated the PC-MHR low relative to the criterion of Technical Viability in spite of the fact that this reactor technology was, only three years ago, the leading candidate for selection as the New Production Reactor. It has also given the PC-MHR a lower rating than other alternatives that have been demonstrated to a lesser degree or about which there are fundamental questions concerning their capability. Nevertheless, the major reason cited by DOE for excluding the PC-MHR from consideration is its lack of "technical maturity". DOE's view may reflect its opinion on the gas

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M-132

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 14 OF 39

turbine design of the MHR recommended by GA versus the earlier steam cycle version of the design. In fact, the reactor technology for both the steam cycle and gas turbine plants is the same. Regarding the gas turbine power conversion system, world leading U.S. and international vendors consider it to be essentially a repackaging of existing industrial and aeronautical technology. Substantial engineering is needed, but there are *no* feasibility issues. *Given adequate funding*, a fully tested turbomachine could be delivered to a site in less than seven years (see Attachment 2).

DOE has rated the PC-MHR the same as all other fission options relative to the criterion of Environment, Safety, and Health. This conclusion ignores the facts that the MHR is widely considered to be the safest reactor option available and that its 47% overall plant efficiency, vs 31-33% for those reactor options deemed to be "reasonable" by DOE, results in substantial reductions in environmental impacts. DOE's own Draft PEIS for Tritium Supply and Recycle makes the safety advantages of the MHR relative to other reactors very clear. 1/14.00.00 cont.

The PC-MHR is rated the same as other reactor technologies that entail construction of a new reactor dedicated to plutonium disposition relative to the screening criterion of Cost Effectiveness. However, DOE provides no quantitative data to support this cost rating or the relative ranking of any of the alternatives in terms of cost effectiveness. The effects of using the gas turbine on life cycle costs of the gas-cooled reactor have yet to be made available to the public because DOE has not made available its report on Phase II of its Plutonium Disposition Study. However, based upon cost analyses using Phase I costing methodology and groundrules, the PC-MHR has a substantial cost advantage over other reactor alternatives (see Attachment 3). Hence, DOE's rating of the PC-MHR as the same as other reactor alternatives against the criterion of Cost Effectiveness is incorrect and *adds to the distorted overall ranking of the PC-MHR.*

The PC-MHR is given a low rating relative to other reactor alternatives with regard to the Timeliness criterion. The 12.5 year initial deployment schedule of the PC-MHR is a conservative estimate based on the schedule for deployment of the New Production Reactor that was developed by DOE and its contractors on the NPR program and was twice independently reviewed and confirmed. In the screening report, DOE ignores *its own schedule and judges the level of certainty in the schedule to* be less than that of the alternatives deemed by DOE to be "reasonable", the deployment schedules for which have never been subjected to the level of scrutiny that was applied to the MHR schedule. (In fact, under more aggressive schedule assumptions, in which first core fuel is produced on the fuel development pilot line, the PC-MHR initial deployment schedule can be reduced to 10 years.) DOE also ignores the fact that the PC-MHR has been shown in DOE's own Plutonium Disposition Study to be capable of completing the plutonium disposition mission within the length of time deemed necessary by DOE. DOE has excluded the PC-MHR from consideration in the PEIS on the basis of an artificial schedule requirement that does not reflect that a small delay in beginning the disposition operation is not significant in the overall timeframe for completing the disposition mission. Use of artificial schedules or administrative guidelines as a basis for declaring an alternative to be unreasonable is clearly in conflict with precedents established by NEPA case law. 1/14.00.00 cont.

The PC-MHR is rated lower than the "reasonable" reactor technologies with regard to the criterion for Fostering Progress and Cooperation with Russia and Others. This assessment is not credible because it ignores the fact that the Russians have repeatedly indicated to DOE and to the Gore-Chernomyrdin Commission their desire to destroy surplus weapons grade plutonium in PC-MHRs to be built at Tomsk-7. It also ignores the fact that the Russians have proposed to DOE a cooperative, cost shared MHR design and development program and have initiated the effort with $1.0 million of their own funding. The Russians have taken no such actions in support of the alternatives deemed "reasonable" by DOE.

The summary screening report rates the PC-MHR as relatively low with regard to the Public and Institutional Acceptance criterion. No explanation is provided for this assessment. The PC-MHR offers distinct advantages relative to this criterion based upon its ability to substantially destroy the plutonium, its superior resistance to diversion and reuse of the residual plutonium in a weapons application, its multipurpose capability, and its unequalled safety characteristics. One can only conclude that DOE has chosen to rate the PC-MHR relatively low against this criterion to be consistent with its apparent intention not to develop advanced reactors in the U.S.. To exclude the PC-MHR at the time of the Record of Decision on the basis of policy matters would be legally permissible; to exclude it from consideration in the PEIS as a reasonable alternative on the basis of policy matters is contrary to precedents established under NEPA case law and is not allowed under Council on Environmental Quality NEPA implementing guidance. 1/14.00.00 cont.

It should also be noted that certain of the alternatives deemed "reasonable" by DOE for consideration in the PEIS and rated higher than the PC-MHR against the Public and Institutional Acceptance criterion will present major, unique public acceptance and policy issues. It is difficult to believe that major policy and public acceptance issues would not be involved in making available large quantities of weapons grade plutonium for disposition either in European nations or in Canada. Not only would major safeguards and security issues be raised, but it would also appear inappropriate to give away to other nations the energy value of the plutonium (which was created at the expense of billions of U.S. taxpayer dollars), to export potential U.S. jobs, and to forego U.S. technology development and deployment in favor of support for foreign technology.

The screening report states that the spent fuel standard was generally accepted, except by "proponents of developmental technologies that could go beyond the spent fuel standard". This statement ignores the letter of December 13, 1994, from Senators Thurmond and Hollings and Representatives Spratt and Spence to Secretary O'Leary that questioned the adequacy of the spent fuel standard. It also continues to ignore the numerous comments in the public scoping meetings which indicated that measures beyond the spent fuel standard would be required to provide ultimate disposition of the plutonium, to ensure that the national security objectives of the plutonium disposition effort would be met, and to extract the maximum possible energy value from the plutonium. The DOE letter of April 14 states that, "all fission options which go beyond the spent fuel standard were deemed unreasonable." By precluding all options that can exceed the spent fuel standard prior to detailed, full evaluation in the PEIS, DOE has withheld important information from 2/01.05.00 cont.

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 16 OF 39

the public regarding the diversion and proliferation resistance of alternatives that exceed the standard relative to those that merely meet it and has perpetuated the myth that these options cannot be deployed in a timely, cost effective manner. 2/01.05.00 cont.

Congress has consistently directed DOE to give full consideration to multipurpose reactors. However, it appears that DOE has not accepted this direction. The Implementation Plan for the PEIS for Fissile Materials indicates that it will not consider any multipurpose option unless a reactor is chosen for tritium supply, and then that it will consider only whether that reactor option might be suited for multipurpose use. No attempt has been made by DOE as part of the NEPA process to compare the costs, benefits, and environmental impacts of a multipurpose reactor against the combined costs, benefits, and impacts of separate projects for the tritium supply and plutonium disposition missions. This approach to the multipurpose reactor appears contrived, will not result in full and fair consideration of multipurpose reactors, and undermines the underlying philosophy of the NEPA process. In a time of growing concern about limits in government resources and about deficit reduction, the manner in which DOE is trying to avoid full and fair consideration of the multipurpose reactor is difficult to understand. 1/14.00.00 cont.

GA is disappointed in the manner in which DOE is approaching these important matters. Under DOE's implementing regulations for NEPA (10CFR1021) there is still an opportunity for DOE to amend the PEIS Implementation Plan to include the PC-MHR and the multipurpose reactor options. We urge DOE to do so. 6/01.05.00 cont.

If you would like to discuss any of these issues in detail, please feel free to call me at any time at (619) 455-2580 or Dave Alberstein at (619) 455-2088.

Sincerely,

A.J. Neylan, Vice President
Power Reactor Group

AJN/DA:da
Attachments

cc:
C.B. Curtis
G. Rudy
J.D. Nulton
P.T. Rhoads
J.M. Turner, DOE-OAK

ATTACHMENT 1 TO GA/DOE-068-95
GENERAL ATOMICS COMMENTS ON DOE's EVALUATION OF THE PC-MHR
AND PROPOSED EXCLUSION OF THE PC-MHR
FROM CONSIDERATION AS A REASONABLE ALTERNATIVE IN THE
PROGRAMMATIC EIS FOR FISSILE MATERIALS DISPOSITION

This attachment provides General Atomics' comments on DOE's treatment of the following matters relative to the PC-MHR and its decision to exclude the PC-MHR from consideration in the PEIS for fissile materials (plutonium) disposition: the assessment of the PC-MHR against the screening criteria, treatment of the spent fuel standard, and DOE's approach to multipurpose options for plutonium disposition and tritium production.

Assessment of the PC-MHR Against the Screening Criteria

Technical Viability:

With regard to the Technical Viability criterion, DOE rates the PC-MHR as low relative to other disposition options. The technical viability of the PC-MHR is rated lower than other technologies that have been demonstrated to a lesser degree or about which there are fundamental questions concerning their capability. For example, the technical viability of the PC-MHR is rated lower than that of the ALMR with pyroprocessing, even though the screening report states that this concept "is still under development in a manner different from its intended purpose." The PC-MHR is also rated lower in technical viability than glass immobilization in DWPF, even though the screening report states that this option would require a specially designed melter to be installed and much of the supporting equipment in DWPF to be re-fitted for this application because DWPF was not designed for criticality control.

The ostensible primary reason given for exclusion of the PC-MHR from consideration in the PEIS is its lack of technical maturity. This reason is, however, inconsistent with previous positions taken by DOE. Only three years ago the MHR was one of the final alternatives under consideration for selection as the New Production Reactor. It was, by most accounts, the leading candidate to be selected had that Record of Decision not been postponed only *one month prior to its scheduled release date. The MHR had been selected as one of the final alternatives for this* vital national security mission following extensive review by the Secretary's Energy Research Advisory Board. In light of this history, it is difficult to justify the DOE decision not to evaluate the MHR in the PEIS for fissile materials disposition. 9/01.05.00

The screening report offers two statements to support the contention that the PC-MHR lacks sufficient technical maturity to be considered in the PEIS as a reasonable alternative for disposition of surplus weapons grade plutonium.

The first statement is the claim that plutonium coated particle fuel is "tested, but not fully demonstrated or proven." In fact, there have been, as DOE is well aware, six successful demonstrations of the capability of weapons grade plutonium coated particle fuel to achieve high levels of plutonium destruction. In contrast, for each of the reactor alternatives that were accepted through the screening process, there is little, if any, irradiation experience whatever with fuels made from plutonium of weapons grade composition. While further demonstration and qualification testing is required for plutonium coated particle fuel (as it will be for weapons grade MOX fuel used in the reactor alternatives deemed "reasonable" by DOE), there have been no feasibility issues identified that would call into question the capability of PC-MHR fuel to perform as required.

M-132

01 05 00 Comment Number 9

Tritium production is a long-term mission of DOE to support national security. Pu disposition is a shorter term mission that DOE must accomplish to meet the Nation's goals in support of its non-proliferation policies. DOE has determined that the "clear and present danger" demands that disposition of Pu be initiated within approximately a decade. Pu disposition can be accomplished in that timeframe using existing technologies to achieve the Spent Fuel Standard.

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 18 OF 39

The second statement concerns the use of the direct cycle power conversion system, a new application of previously developed components. As noted several times by GA in reports to DOE and in other correspondence with DOE, development of the power conversion system is not on the critical path for deployment of the PC-MHR. The system has been evaluated by two major turbogenerator vendors that are recognized authorities in direct cycle applications. Both have judged that the power conversion system is essentially a repackaging of existing industrial and aeronautical technology. Substantial engineering is needed, but there are no feasibility issues. Given adequate funding, a fully tested turbomachine could be delivered to a site in less than seven years, a schedule that would support deployment on the time scale needed for plutonium disposition (see Attachment 2).

In addition, DOE has had in its possession since May 1993 information on the capability of the gas-cooled reactor to destroy weapons grade plutonium using a more conventional and previously demonstrated steam cycle power conversion system. However, DOE has chosen to ignore this information in developing its rationale for eliminating the MHR from consideration.

Environment, Safety, and Heath:

The summary screening report rates the PC-MHR the same as all other fission options relative to the criterion of Environment, Safety, and Health. This conclusion ignores the facts that 1) the MHR is widely considered to be the safest reactor option available, 2) its 47% overall plant efficiency, vs 31-33% for those reactor options deemed to be "reasonable" by DOE, results in substantial reductions in environmental impact relative to these other reactor alternatives, and 3) gas-cooled reactors have a proven track record of substantially lower radiation exposure to plant workers than any other power reactor type.

The inherent passive safety characteristics of the PC-MHR offer distinct safety advantages over the reactor types that DOE has deemed "reasonable" for consideration in the PEIS. The safety design objectives of the PC-MHR are met through a combination of inherent safety features and design selections that enable passive heat transfer under accident conditions (even loss of coolant or loss of forced coolant circulation) while maintaining fuel temperatures below damage limits. The reactor core is made of all refractory materials that can not melt at high temperatures. The core is slow to heat up under accident conditions, with thermal transients occurring over periods of hours and days rather than seconds or minutes as for other reactor types. Almost all fission products are retained in the refractory coated fuel particles during normal operation and accident conditions, and radioactive release is small. Radiation exposure at the site boundary is less than the Environmental Protection Agency's Protective Action Guidelines, so no off-site actions such as sheltering or evacuation of the public are required, and the risk to public health and safety is minimized. DOE's own Draft PEIS for Tritium Supply and Recycle makes the safety advantages of the MHR relative to other reactors very clear.

Cost Effectiveness:

The PC-MHR is rated the same as other reactor technologies that entail construction of a new reactor dedicated to plutonium disposition relative to the screening criterion of Cost Effectiveness. However, DOE provides no quantitative data to support this ranking or the relative ranking of any of the alternatives in terms of cost effectiveness. The only data that DOE has published regarding plutonium disposition costs are those in its report to Congress that was published following Phase I of the Plutonium Disposition Study. The Phase I report provided relative life cycle costs for various reactor options for plutonium disposition as a function of installed capacity. Costs were developed based on an economic model developed by Oak Ridge National Laboratory personnel under contract to DOE. Information on the gas-cooled reactor in Phase I of the study was developed for the earlier steam cycle version of the plant.

In Phase II of the Plutonium Disposition Study, GA changed its design to incorporate the direct Brayton cycle gas turbine power conversion system. The primary motivation for this change was the improved plant economics, which result from power conversion equipment simplification and an increase in net plant efficiency from 38% to 47%. The increased efficiency results in increased revenue from sale of electricity to offset the costs of engineering development, design, construction, and operation of the PC-MHR.

Although the report to Congress on Phase II of the Plutonium Disposition was due to be delivered to Congress during the Fall of 1994, DOE has yet to release the report. It is GA's understanding that the report has been completed since the end of 1994. Hence, the effects of changing to the gas turbine on life cycle costs of the gas-cooled reactor have yet to be made available to the public. Using the Phase I economic model, which was provided at DOE's request to GA by the staff at Oak Ridge, GA has calculated the life cycle costs of the PC-MHR and compared them against those of the other reactor technologies evaluated during Phase I of the study. The results show that the life cycle costs of the PC-MHR are substantially lower than those of all other reactor alternatives (see Attachment 3). Informal confirmation of these results has been obtained.

DOE has assumed that alternatives that exceed the spent fuel standard will cost substantially more to develop and deploy than those which merely meet the standard, and it has used this assumption as part of its rationale for eliminating as unreasonable options that exceed the standard. These PC-MHR cost analysis results indicate that this assumption is not well founded.

It is GA's understanding that one of the reasons for the delay in releasing the Phase II Plutonium Disposition Study report was that Oak Ridge was asked by DOE to make changes in the cost analyses in the report. GA is unaware of whether the economic model used in Phase II of the Plutonium Disposition Study is substantially different from that used in Phase I. Hence, GA is also unaware of whether the distinct cost advantage of the PC-MHR will be confirmed by the Phase II report. Nevertheless, based upon available information it appears that the PC-MHR has a substantial cost advantage over other reactor alternatives and that DOE's rating of the PC-MHR as the same as other reactor alternatives against the criterion of Cost Effectiveness is incorrect and adds to the distorted overall ranking of the PC-MHR.

Timeliness:

The PC-MHR is given a low rating relative to other reactor alternatives with regard to the Timeliness criterion. The 12.5 initial deployment schedule for the PC-MHR is a conservative estimate based on the schedule for deployment of the New Production Reactor that was developed by DOE and its contractors on the NPR program and was twice independently reviewed and confirmed. In the screening report, DOE ignores its own schedule and judges the level of certainty in the schedule to be less than that of the alternatives deemed by DOE to be "reasonable", the deployment schedules for which have never been subjected to the level of scrutiny that was applied to the MHR schedule. (In fact, under more aggressive schedule assumptions, in which first core fuel is produced on the fuel development pilot line, the PC-MHR initial deployment schedule can be reduced to 10 years.)

Because the initial deployment schedule for the PC-MHR is a mere 30 months longer than DOE's arbitrary criterion of a ten year initial deployment schedule, and even though the PC-MHR has been shown in DOE's own Plutonium Disposition Study to be capable of completing the plutonium disposition mission within the length of time deemed necessary by DOE, DOE claims that the PC-MHR does not meet its requirement for timely deployment. DOE ignores the fact that the total duration of the plutonium disposition mission (several decades) will dwarf the 30 month difference in initial deployment schedule of the PC-MHR, and that during the entire disposition mission duration plutonium pits and other forms of weapons useable plutonium will be maintained, initially in "interim storage", and will be subject to current vulnerabilities unless safer, more secure modes of

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 20 OF 39

storage are implemented. The emphasis on early, timely deployment should be more properly placed on "long term storage" options rather than disposition options.

DOE has excluded the PC-MHR from consideration in the PEIS on the basis of an artificial schedule requirement that does not reflect that a small delay in beginning the disposition operation is not significant in the overall timeframe for completing the disposition mission. Use of artificial schedules or administrative guidelines as a basis for declaring an alternative to be unreasonable is clearly in conflict with precedents established by NEPA case law.

Fostering Progress and Cooperation with Russia and Others:

The PC-MHR is rated lower than the "reasonable" reactor technologies with regard to the criterion for Fostering Progress and Cooperation with Russia and Others. This assessment is not credible because it ignores the fact that the Russians have repeatedly indicated to DOE and to the Gore-Chernomyrdin Commission their desire to destroy surplus weapons grade plutonium inventory in PC-MHRs at Tomsk-7. It also ignores the fact that the Russians have proposed to DOE a cooperative, cost shared MHR design and development program and have initiated the effort with $1.0 million of their own funding, matched with an equal amount of funding by General Atomics. The Russians have taken no such actions in support of the alternatives deemed "reasonable" by DOE.

In the April 14, 1995, letter to GA, DOE implies that the 12.5 year initial deployment schedule for the PC-MHR in the U.S. disqualifies it for consideration for deployment in Russia and results in its low rating relative to this criterion. This position ignores the fact that deployment in Russia could be accomplished more quickly and less expensively than in the U.S.. Furthermore, it arbitrarily assumes that Russia would agree to the same screening criteria and weighting factors that DOE has deemed appropriate for selection of options in the U.S.. This is clearly not appropriate, as evidenced by the public statements of Russia on plutonium disposition. If DOE wants to foster progress and cooperation with Russia in plutonium disposition, it must deal with the Russians in a manner that addresses the criteria that are important to Russia. The Russians have judged that the PC-MHR provides an approach to plutonium disposition that addresses these criteria. DOE's apparent lack of willingness to support development of the gas-cooled reactor in the United States is not an appropriate basis for down-rating its ability to foster progress and cooperation with Russia.

Public and Institutional Acceptance:

The summary screening report rates the PC-MHR as relatively low with regard to the Public and Institutional Acceptance criterion. No explanation is provided for this assessment. However, the screening report indicates that there were three elements that contributed to this criterion:

- Ability to create a sustainable consensus
- Socioeconomic impacts
- Policy/statute compatibility

There are no indications that the PC-MHR could not create a sustainable consensus or would have net socioeconomic impacts that are particularly adverse relative to other alternatives for plutonium disposition. In fact, as discussed below, the PC-MHR has significant advantages with regard to public acceptance relative to the reactor alternatives deemed by DOE to be "reasonable". Furthermore, there are no indications that selection of the PC-MHR would require significant legislative or regulatory changes.

Hence, one can only conclude that DOE has purposely rated the PC-MHR relatively low against this criterion to comply with an apparent intention not to develop advanced reactors in the U.S.. To exclude the PC-MHR at the time of the Record of Decision on the basis of policy matters would be legally permissible; to exclude it from consideration in the PEIS as a reasonable alternative on the basis of policy matters is contrary to precedents established under NEPA case law (Natural Resources Defense Council v. Morton) and is not allowed under Council on Environmental Quality NEPA implementing guidance (Memorandum, Questions and Answers About the NEPA Regulations, 46 Federal Register, 18026, 1981).

The PC-MHR offers distinct advantages over other reactor options with regard to public acceptance. Reactor disposition of surplus weapons grade plutonium is unlikely to be well received by the general public unless the specific reactor technology chosen offers a clear departure from and clear improvement over the nuclear reactor technologies that are in common use today and that have enjoyed less than enthusiastic public acceptance. The PC-MHR represents such a departure. The following points, which were presented by GA in its Phase II Plutonium Disposition Study report to DOE, should have been considered by DOE with regard to public acceptance of the PC-MHR for plutonium disposition.

Use of the PC-MHR for consumption of weapons-grade plutonium offers numerous advantages relative to other plutonium disposition options. These advantages are derived from its high burnup capability, versatility, and inherent, passive safety characteristics, all of which will further contribute to public acceptance.

To obtain public acceptance of the chosen plutonium disposition option, the approach taken must result in a discharge product with minimal attractiveness for weapons applications, and hence no incentive for theft, diversion, or reprocessing. The high burnup capability of the PC-MHR coated particle fuel gives it the demonstrated capability to destroy 90% or more of the initially charged plutonium-239 (and 65% or more of the initially charged total plutonium) so that the weapons-grade material is truly consumed. This level of plutonium destruction is achieved in a single pass through the reactor. The PC-MHR is the only plutonium disposition reactor option that can achieve such high plutonium destruction levels without reprocessing.

Achievement of high burnup is important for obtaining public acceptance of reactor disposition of excess weapons grade plutonium. As discussed in the National Academy of Sciences report on plutonium disposition, the large and growing inventory of plutonium in discharged commercial reactor fuel is of concern with regard to potential proliferation. Use of a reactor technology that achieves higher burnup than that represented by the "spent fuel standard" will enhance the likelihood of public acceptance because it will not be perceived as adding to the existing problem to the extent of other candidate reactor technologies.

Achievement of high burnup without reprocessing is important to both public and political acceptance of reactor disposition of surplus weapons grade plutonium. Reprocessing of spent nuclear fuel in the U.S. has not been allowed under government policy for several years due to concerns regarding nuclear proliferation from the commercial fuel cycle. Much of the opposition to reactor-based plutonium disposition is based on the concern that it would be used as an opportunity to revive a plutonium-based nuclear energy economy. All of the reactor technologies for plutonium disposition that DOE has chosen to include in the PEIS use fuel types that generate new plutonium during operation. The PC-MHR contains no fertile fuel material; all fissions in the core are plutonium fissions, and no new plutonium is created. The PC-MHR is not commonly associated with development of a plutonium based economy, and its deep burn capability could not result in a signal to other nations that rely on plutonium recycling that the U.S. endorses use of plutonium in fuel cycles that create additional plutonium suitable for use in reactors or in weapons applications.

The discharged fuel elements from the PC-MHR are suitable for direct disposal, without further processing (and

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 22 OF 39

associated opportunity for diversion), in a permanent repository. The discharged fuel is highly undesirable for use as a nuclear weapons material either by terrorists or governments because it is difficult to divert, its plutonium content is difficult to separate, and even if separated the discharged plutonium is difficult to use in a weapons application.

Diversion of the discharged fuel elements is difficult for all the reasons that apply to any reactor spent fuel (high radioactivity, large mass, extensive safeguards and security, etc.), but also for one reason that is unique to the PC-MHR: low plutonium content per fuel element. While the plutonium content in a single spent fuel assembly from a weapons grade MOX-fueled light water reactor (one of the alternatives deemed "reasonable" by the DOE) is of sufficient quantity to use in a weapons application, one would have to divert up to 102 PC-MHR spent fuel elements (each weighing about 250 pounds) to obtain a similar quantity of discharged plutonium. This would require the diversion of about seventeen truckloads of spent fuel shipping casks or three railcars of multipurpose containers containing PC-MHR spent fuel vs one truckload of spent fuel from a weapons grade MOX-fueled light water reactor. Even if such a large quantity of spent fuel were diverted, the technology for separating plutonium from gas-cooled reactor spent fuel has not been developed, in contrast to the light water reactor, for which plutonium separation technology is well established, being practiced, and is known throughout the world. Finally, although any mixture of plutonium isotopes can, in principle, be used to make a nuclear device, the plutonium discharged from the PC-MHR is, due to the high burnup obtained, particularly high in plutonium-240, 241, and 242 content, which makes it substantially more difficult to use in weapons applications than the discharge from reactors that do not achieve as high a burnup level. GA notes that these advantages were recognized also by DOE in the screening summary report, in which the PC-MHR was rated relatively high against other options for the criterion of Resistance to Retrieval, Extraction, and Reuse. However, these characteristics suggest a substantially larger advantage for the PC-MHR than the nominal difference suggested in the DOE analysis.

These matters are straight forward, easily explained, and understandable for a non-technical audience. Thus, public acceptance of use of the PC-MHR for plutonium disposition is likely to be more readily obtained than for the alternatives deemed "reasonable" by the DOE for consideration in the PEIS.

In addition to its suitability for plutonium consumption, the PC-MHR offers other advantages that would enhance public acceptance. One of the most important of these is its versatility. The PC-MHR offers effective use of government money through its ability to perform multiple missions while simultaneously providing electrical generation and advancing power generation science and technology.

Tritium production capability can be provided as needed. The tritium production capability of the gas-cooled reactor was well established on the DOE New Production Reactor Program. The amount of tritium produced by the PC-MHR can be varied by altering core fuel loading or the loading of tritium-producing targets. It can be produced while consuming surplus weapons grade highly enriched uranium in one or more reactor modules dedicated to tritium production, or it can be produced in a coproduction mode while simultaneously consuming surplus weapons grade plutonium. While some have offered the opinion that plutonium disposition and tritium production missions should not be combined and that selection of plutonium disposition technology should not be influenced by the tritium production capability of the candidate technologies, this view does not recognize the importance of using flexible technology for these missions and of making efficient use of government money in a time when federal budgets are tight and deficit reduction is a high priority. A multipurpose plant that combines the plutonium disposition and tritium production missions would not only be economically efficient, but it would also minimize overall environmental impacts by conducting both missions on one site. All of these factors are important considerations in achieving public acceptance of use of reactors for plutonium disposition, and the PC-MHR is particularly well suited in this regard.

The inherent passive safety characteristics of the PC-MHR, as described in the discussion of the Environment, Safety, and Heath criterion, offer distinct safety advantages over the reactor types that DOE has deemed "reasonable" for consideration in the PEIS, and this will also enhance public acceptance. The simple approach to safety design used for the PC-MHR is straight forward, easily explained, and understandable for a non-technical audience. Because the design of the PC-MHR is so different from that of other reactor alternatives, it is less likely to be seen by the public as an offering of more of the same reactor technology that has had highly publicized safety problems and has met to date with only limited public acceptance. It is noteworthy that throughout the initial licensing proceedings and subsequent operating lifetime of the Fort St. Vrain gas-cooled reactor in Colorado, no major intervenor opposition to the plant based upon safety concerns occurred. The safety characteristics of the MHR have been significantly enhanced over those of Fort St. Vrain.

While public acceptance of any approach to plutonium disposition will present challenges, the PC-MHR offers distinct advantages in this regard based upon its ability to substantially destroy the plutonium while not developing a plutonium fuel cycle, its superior resistance to diversion and reuse of the residual plutonium in a weapons application, its multipurpose capability, and its unequalled safety characteristics.

Finally, it should be noted that certain of the alternatives deemed "reasonable" by DOE for consideration in the PEIS and rated higher than the PC-MHR against the public and institutional acceptance criterion will present major, unique public acceptance and policy issues. It is difficult to believe that major policy and public acceptance issues would not be involved in making available large quantities of weapons grade plutonium for disposition either in European nations or in Canada. Not only would major safeguards and security issues be raised, but it would also appear inappropriate to give away to other nations the energy value of the plutonium (which was created at the expense of billions of U.S. taxpayer dollars), to export potential U.S. jobs to other countries, and to forego U.S. technology development and deployment in favor of support for foreign technology. Public acceptance and policy issues would also be raised for the alternative of using existing commercial reactors for plutonium disposition, making a sustainable consensus difficult to achieve.

The Spent Fuel Standard

The screening report states that the spent fuel standard was generally accepted, except by "proponents of developmental technologies that could go beyond the spent fuel standard", and your letter of April 14 states that, "all fission options which go beyond the spent fuel standard were deemed unreasonable." These statements ignore the letter of December 13, 1994, from Senators Thurmond and Hollings and Representatives Spratt and Spence to Secretary O'Leary that questioned the adequacy of the spent fuel standard. They also continue to ignore the numerous comments in the public scoping meetings, such as those at Savannah River, Idaho Falls, Los Alamos, and Livermore, which indicated that measures beyond the spent fuel standard would be required to ensure that the national security objectives of the plutonium disposition effort would be met and that maximum possible energy value would be extracted from the plutonium. Rather than providing a representative sampling of the comments made in support of exceeding the spent fuel standard, DOE merely provides in the implementation plan and the screening summary report a limited, unrepresentative selection of these comments and then dismisses them by claiming that the appropriateness of the spent fuel standard was reaffirmed by the scoping process.

The implementation plan states that detailed evaluations of the diversion and proliferation aspects of the various alternatives to be evaluated in the PEIS will be performed as part of the Record of Decision process. This evaluation should have been conducted and the results should have been made available to the public as part of the screening process so that the public could be fully informed about the implications of merely meeting the spent fuel standard rather than exceeding it. An open evaluation of these matters would have given the public an opportunity

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 24 OF 39

to judge for itself the acceptability of the spent fuel standard and/or the merits of substantially exceeding the spent fuel standard. By precluding all options that can exceed the spent fuel standard prior to detailed, full evaluation in the PEIS, DOE has withheld this important information from the public and has perpetuated the myth that these options cannot be deployed in a timely, cost effective manner.

Regardless of the question of the acceptability of the spent fuel standard, the PC-MHR is a reasonable alternative for plutonium disposition based on its superior safety and environmental characteristics, cost characteristics, diversion and proliferation resistance, spent fuel form, and level of technical maturity as evidenced by its consideration under the New Production Reactor Program. The ability of the PC-MHR to exceed the spent fuel standard is a readily achievable additional benefit, and the fact that it has the ability to exceed the standard is not an acceptable basis for its exclusion from consideration in the PEIS.

Mutipurpose Reactor Options

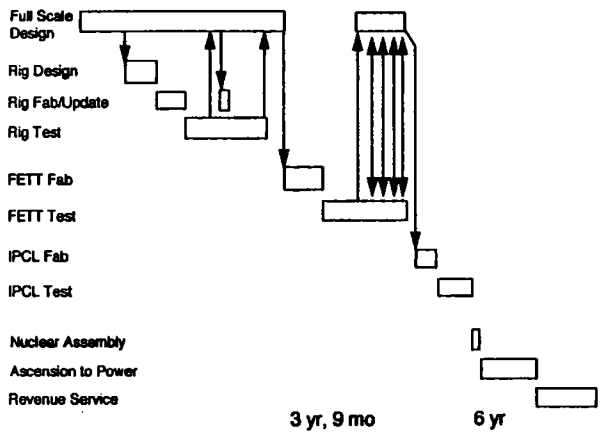
When work on the New Production Reactor was terminated, Congress authorized and appropriated funds in FY-93 and directed the DOE to undertake assessments of both light water reactor and gas-cooled reactor systems for the multipurpose functions of plutonium consumption, tritium production, and electricity production. The 1995 Energy and Water Appropriations conference report directed the DOE to submit to Congress, within 180 days, a report on the technological feasibility of a multipurpose reactor for the disposition of plutonium and the production of tritium. In a letter to the Secretary of Energy dated December 13, 1994, Senators Thurmond and Hollings and Representatives Spence and Spratt expressed their support for inclusion of a deep burn multipurpose reactor option in the PEISs being prepared by DOE for both tritium production and plutonium disposition.

As indicated, Congress has consistently directed DOE to give full consideration to multipurpose reactors. However, it appears that DOE has not accepted this direction. The Draft PEIS for Tritium Supply and Recycle provides only a comparison of the environmental impacts of tritium production technologies with the impacts of their multipurpose counterparts. The Implementation Plan for the PEIS for Fissile Materials indicates that it will not consider any multipurpose option unless a reactor is chosen for tritium supply, and then that it will consider only whether that reactor option might be suited for multipurpose use. Therefore, if DOE chooses an accelerator for tritium production, multipurpose reactors will not be considered at all for plutonium disposition.

This approach to the multipurpose reactor appears contrived and will not result in full and fair consideration of multipurpose reactors for tritium production and plutonium disposition. It also compromises the underlying philosophy of the NEPA process by effectively precluding alternatives that should result in less total environmental impact than would result from separate projects for each mission. As these evaluations are currently organized by DOE, no effort is being made to compare the costs, benefits, and environmental impacts of multipurpose reactors against the combined costs, benefits, and environmental impacts of the two individual mission technologies. It may well be that DOE could choose the accelerator for tritium production and a nonreactor alternative for plutonium disposition and never provide to the public an assessment of whether a multipurpose reactor could conduct both missions at less cost to the taxpayer and with less total environmental impact. In a time of growing concern about limits in government resources and about deficit reduction, the manner in which DOE is trying to avoid full and fair consideration of the multipurpose reactor is difficult to understand.

DEVELOPMENT SCHEDULE

Turbomachine Development Schedule Shows First Engine to Test in Less Than 4 Years



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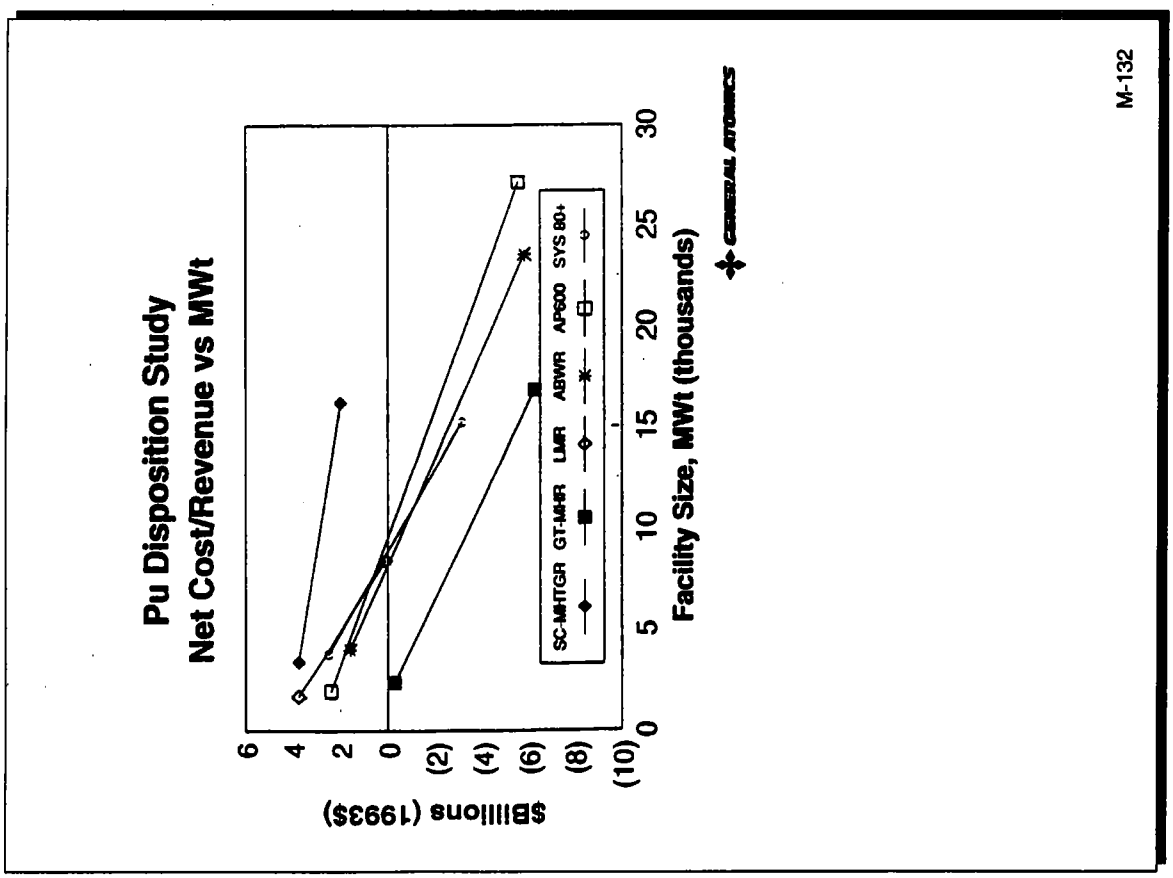
GENERAL ATOMICS

M-132

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 26 OF 39



ATTACHMENT 3 TO GA/DOE-027-96
ADDITIONAL GENERAL ATOMICS COMMENTS
ON THE DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT
FOR STORAGE AND DISPOSITION OF WEAPONS-USEABLE FISSILE MATERIALS

The following comments on the draft Programmatic EIS are in addition to those in References 1 and 2, copies of which are provided as Attachments 1 and 2, respectively.

Multipurpose Reactors

In References 1 and 2, GA expressed its concerns regarding DOE's approach to consideration of multipurpose reactors in the Programmatic EIS. Subsequently, statutory and Conference Report language from the FY-1996 Defense Authorization Bill (S.1124) has directed that funds authorized to be appropriated to the DOE for Fissile Materials Disposition shall be available for "completing the evaluation of, and commencing implementation of, the interim- and long-term storage and disposition (including storage and disposition through the use of advanced light water reactors and gas turbine gas-cooled reactors) of fissile materials...." The Bill also states that, "sufficient funds shall be made available for the complete consideration of multipurpose reactors for the disposition of fissile materials in the programmatic environmental impact statement of the Department."

These technical assessments, cost/benefit comparisons, and related evaluations would, in the case of the "gas turbine gas-cooled reactor", be a follow-on to the plutonium disposition evaluations performed by General Atomics (GA) for the Gas Turbine Modular Helium Reactor (GT-MHR) during fiscal years 1993 - 1995 under the direction of the DOE in accordance with the provisions of the FY-93 DOE Appropriations Bill.

These studies concluded that the GT-MHR can offer substantial capabilities for the simultaneous disposition of surplus weapons grade plutonium and production of tritium. Evaluations to date indicate that a single 2400 MWt standard plant, comprised of four reactor modules, can process more than 80 metric tonnes of surplus weapons grade plutonium over its 40 year design operating lifetime while concurrently producing tritium at 3/8 of the original New Production Reactor Goal Quantity and generating electricity for sale to offset project costs. The 4x600 MWt modular design provides standardization of construction, enhanced availability, flexibility in mission, and meltdown proof reactor safety. The plant achieves ~47% net plant efficiency, generates 1144 MWe, and significantly reduces environmental impact compared to alternative reactor concepts. The resulting spent fuel is suitable for permanent geologic disposal without further treatment. Design and development costs are ~$750M. The first reactor module could be operational in about 10 years (Ref. 3). 9/01.05.00 cont.

In Reference 4, GA submitted to DOE a recommended program plan for evaluation of the multipurpose capabilities of the GT-MHR which, if accepted and implemented by DOE, would provide the information needed by DOE to comply with the FY-96 Authorization Bill. DOE's response to the recommended program plan (Ref. 5) indicated that DOE believes that previously

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 28 OF 39

conducted studies sufficiently addressed the gas-cooled reactor both for tritium production and for multipurpose use. The response did not, however, indicate how DOE intends to respond to the requirements of the FY-96 Defense Authorization Bill.

The Draft Programmatic EIS for Fissile Materials makes only minimal reference (a three page Appendix N) to multipurpose reactors as an option for fissile materials disposition. It does so in a manner that is not consistent with the spirit or the intent of the National Environmental Policy Act (NEPA) and does not comply with the provisions of the FY-96 Authorization Bill. The discussion is limited to the possibility that an existing LWR could be used simultaneously for plutonium disposition, tritium production, and generation of revenue through production and sale of electricity. The first sentence of Appendix N of the draft Programmatic EIS provides an incorrect definition of multipurpose reactors as reactors that use plutonium in the form of mixed oxide (MOX) fuel. This definition precludes the use of the gas cooled reactor, which uses only fissile plutonium fuel instead of MOX, in a multipurpose application. Reference is then made to the Record of Decision and the Programmatic EIS for Tritium Supply and Recycling, in which the multipurpose reactor was "preserved as an option for future consideration". Contrary to the requirements of the FY-96 Authorization Bill, no discussion is provided of multipurpose advanced light water reactors or of multipurpose gas turbine modular helium reactors. 10/11.01.08

As noted by GA in its comments to DOE on the Programmatic EIS for Tritium Supply (Ref. 6), the treatment of the multipurpose options in that document is superficial, inadequate, and inconsistent with the requirements of the National Environmental Policy Act. The evaluation is neither full nor fair. The environmental impacts of the multipurpose options are compared only with those of the tritium production options. A full and fair assessment would compare the impacts of the multipurpose options with those of separate plutonium disposition and tritium production options combined. Such a comparison was not provided in the Programmatic EIS for Tritium Supply and Recycling, and if it is not provided in the Final Programatic EIS for Storage and Disposition of Weapons-Useable Fissile Materials, DOE will not have complied either with NEPA or with the FY-96 Authorization Bill.

Disposition Schedule

Before the Draft Programmatic EIS was prepared, all potential options for plutonium disposition were screened using criteria given in Reference 7. The criteria are similar to those used by the National Academy of Sciences (NAS) in its 1994 report (Ref. 8). One of the criteria, timeliness, was initially defined by DOE as follows:

> "The technology concept should be demonstrated within ~20 years and disposition should be completed within ~50 years."

As stated, this criterion would have allowed for development of advanced, deep-burn reactor technologies for plutonium disposition, including the GT-MHR. Of equal significance, this criterion would have allowed for a single, approximately 1GW(e) plant (GT-MHR or LWR) to

M-132

11 01 08 Comment Number 10

It was DOE's decision, during the planning for environmental documents in compliance with NEPA, that the TSR PEIS include the analysis of the Multipurpose Reactor Option. Because tritium supply is a long-term mission of DOE compared to the shorter term mission of Pu disposition, the Storage and Disposition PEIS would incorporate, by reference, information developed in the TSR PEIS. This approach is in compliance with the intent of NEPA. Clarification was added to Appendix N in response to the *FY-96 Authorization Bill.*

complete the disposition mission (50 metric tonnes of surplus weapons grade plutonium) over the expected operating lifetime of the plant. In other words, the potential environmental impacts would have been limited to those for a single plant.

In Reference 7, the DOE somewhat arbitrarily changed the timeliness criterion to "require that the disposition be able to start within about a decade and be able to be completed within about three decades." The reason stated by DOE in Reference 7 for adopting this shorter schedule was input from the public and stakeholders "relating to the urgency of taking action stemming from the 'clear and present danger' associated with these materials." However, this reasoning is not supported by the DOE's questionnaire data reported in Appendix A of Reference 7 (see Figures 1 and 2, taken from Reference 7). From Figure 1, five of the nine criteria received higher rankings of "very important" than given to timeliness. From Figure 2, the ranking of timeliness relative to the other criteria indicates clearly that the questionnaire respondents viewed timeliness as being of secondary importance. 11/01.02.00

Other factors also do not justify forcing the plutonium disposition mission to a shorter schedule. According to the draft Programmatic EIS, the DOE also proposes to provide a long-term, 50-year storage system for plutonium and highly enriched uranium declared to be non-surplus. The non-surplus material is categorized into naval nuclear fuel, strategic reserves, material for weapons research and development, and programmatic materials. The DOE acknowledges that some of the non-surplus material could be classified as surplus material in the future. During the disposition mission, it is quite possible that surplus and non-surplus material would be stored and secured at common locations. For plutonium being stored and secured at a given location, it would be absurd to determine that material classified as surplus poses a "clear and present danger," while material classified as non-surplus does not pose a similar risk, particularly when the classification boundary could change over time. The "clear and present danger" argument does not justify adoption of the more urgent disposition schedule, since fissile material of potentially unknown classification (surplus or non-surplus) will be in storage for time periods exceeding the more urgent disposition schedule. 12/01.06.00

The DOE acknowledges that the risks for theft and diversion of fissile material are greater in Russia than in the U.S., because of the less stable political climate in Russia. Perhaps the justification for the more urgent schedule is to encourage the Russians to adopt a similarly urgent schedule, thereby reducing the risks of theft and diversion. While plausible, this strategy is not consistent with desires expressed by the Russians. The Russians have actively encouraged development of the GT-MHR for plutonium disposition. As part of a private, cost-sharing initiative with General Atomics and Framatome, Russian engineers and scientists are presently working on the GT-MHR design. At the recent Third International Policy Forum: Management and Disposition of Nuclear Weapons Materials (Lansdowne, VA, March 19-22, 1996) high level Russian representatives confirmed their strong support for continuing development of the GT-MHR for plutonium disposition. Despite growing international support, the DOE has not been receptive to this private initiative and has implied that the GT-MHR could not be deployed in Russia in a sufficiently timely manner relative to DOE's schedule requirements. From Figure 2, it is interesting to note that the criterion "Influence on Russia and Other Countries" was rated 13/01.03.00

M-132

01 02 00 Comment Number 11

The Department of Energy did not arbitrarily change the timeliness criteria. DOE asked for public input on the proposed screening criteria through a questionnaire which used the approximately 20- to 50-year timeframe for the disposition timeliness criteria. There were some responders to the questionnaire who felt that this timeframe was appropriate. However, the majority of responders expressed opinions that the timeliness criteria was moderate to very important and that the timeframe (20 to 50 years) was too long. Further, the NAS Report states that disposition using Pu as fuel in reactors could begin within 10 years and be completed within 20 to 40 years.

01 06 00 Comment Number 12

The "clear and present danger" is of more concern with Russian materials than with U.S. materials. The "clear and present danger" applies to all materials that are weapons-usable, whether or not they are surplus. The sooner the United States and Russia can disposition surplus materials, the sooner the total volume of material can be reduced. Thus, the "clear and present danger" can be reduced.

The "clear and present danger" cannot be eliminated unless all material is declared surplus and dispositioned. Since this is not likely to occur in the foreseeable future, a safe, secure, and inspectable storage capability, such as that evaluated in the PEIS, must be implemented to assure that non-proliferation objectives in both countries are met.

01 03 00 Comment Number 13

Comment noted. DOE is encouraging the Russians to pursue timely Pu disposition by offering technical assistance, conducting joint assessments of the various disposition technologies, and planning joint demonstrations of some of the technologies to remove uncertainties in their viability.

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 30 OF 39

as being of somewhat greater importance than timeliness.

Finally, in its 1995 report on reactor-related options for plutonium disposition (Ref. 9), the NAS viewed the shorter schedule as a "very severe constraint" that did not provide a useful basis for comparative evaluations. For comparing the various reactor options, the NAS assumed that 50 metric tonnes of plutonium would be processed over the nominal lifetimes of the reactors.

The impacts of adopting the unnecessarily shorter plutonium disposition schedule are:

The shorter schedule eliminates advanced, deep-burn reactor technologies, such as the GT-MHR, from further consideration.

The required number of approximately 1 GW(e) plants is increased from one to two, and the associated environmental impacts are doubled.

The potential for a strong international cooperative program on plutonium disposition and proliferation-resistant fuel cycles that is of great interest to Russia is hampered.

The Programmatic EIS should be expanded to include a flexible schedule that can accommodate disposition of plutonium over the expected reactor lifetime, and advanced, deep-burn reactor options should be evaluated as part of the EIS process. The "clear and present danger" argument is highly subjective and open to a wide range of interpretation. This argument should not be used to eliminate alternatives that require only a slightly longer schedule than that currently dictated by DOE. 14/01.02.00 15/01.04.00

Final Waste Form Characteristics

An important issue for any plutonium disposition strategy is the suitability of the final waste form for permanent disposal. Respondents to the DOE questionnaire (Ref. 7) recommended additional criteria that should be used to screen plutonium disposition technologies, including several criteria related to final waste form characteristics. During the screening process and preparation of the draft Programmatic EIS, DOE gave little consideration to final waste form characteristics and resulting long term environmental impacts, other than the annual volume of high-level waste generated by the various disposition alternatives. 16/01.05.00

Volume alone is a poor measure of the environmental impact of the final waste form. In fact, a larger volume may be an environmental attribute, since the dilution of plutonium (residual plutonium if the waste is spent fuel) provides greater resistance to diversion and proliferation and their substantial negative environmental impacts. Also, geologic repository loading density and required repository land area are determined by decay heat load of the spent fuel and not by physical volume. For the GT-MHR, the annual volume of spent fuel would be about ten times that from a commercial LWR or plutonium disposition LWR, on an equivalent electrical energy basis, but the required land area for GT-MHR spent fuel would be about one-half that required for LWR spent fuel. The greater volume of GT-MHR spent fuel is a consequence of

M-132

01 02 00 Comment Number 14

The cost and schedule analysis was presented in a separate report available for public review beginning in late July 1996. The Advanced Deep Burn Reactors Option, including the MHRs, was considered in the screening process. Notwithstanding the many potential benefits of their use, the technical immaturity would call for costly and lengthy development and demonstration efforts to bring them to a viable status. The Screening Committee decided that the increased Pu burn up offered by this option would not counterbalance its cost, schedule, or technical risks, and therefore, eliminated this option from further consideration.

01 04 00 Comment Number 15

The term "clear and present danger" was used by the NAS in their report on the potential proliferation of weapons materials and referred to the situation in Russia and the former Soviet Republics where weapons materials are not subject to the same strict controls as in the United States. The incentive for choosing technologies that can disposition U.S. materials on a relatively short schedule is to provide an equivalent incentive for Russia to also move forward quickly with disposition.

01 05 00 Comment Number 16

The PEIS provides a comparative analysis of the HLW forms in Appendix H. The purpose of the Proposed Action is to convert the surplus weapons-usable Pu into a form that meets the Spent Fuel Standard for proliferation resistance. Existing, proven waste forms are sufficient to meet the needs of the Proposed Action.

the low power density of the GT-MHR core, which helps to provide inherent, meltdown-proof safety during normal operation and hypothetical accidents. Approximately 83% of the GT-MHR spent fuel volume is high-purity, nuclear-grade graphite, which by itself would be classified as low-level waste. The high-level waste is confined to the fuel compacts, and the bulk of this waste (99.9%) is contained within the coating layers of the fuel particles. The GT-MHR would destroy and degrade weapons-grade plutonium well beyond the commercial LWR spent fuel standard. The final waste form would be rendered permanently resistant to proliferation, would be contained effectively for geologic time periods by the multiple layers of highly corrosion-resistant ceramic coatings (Refs. 10 through 12), and would be well suited for permanent disposal in a geologic repository. The graphite is also highly resistant to corrosion (Ref. 13) and would serve as an additional protective overpack after permanent disposal. The long-term environmental impacts of permanent disposal would be significantly reduced, and potential high consequence scenarios would be eliminated, including recovery of spent fuel canisters to obtain plutonium for weapons (i.e., the "plutonium mine" issue would be eliminated) and large-scale radionuclide releases caused by severe climatic changes and/or increased seismic activity (i.e., much less reliance would be placed on the geosphere for radionuclide containment). With regard to these issues, GT-MHR spent fuel would be a nearly ideal waste form for permanent disposal (Ref. 14).

In screening reactor technologies for plutonium disposition, the DOE has determined that the commercial LWR "spent fuel standard" was a sufficient end point. The basis for the spent fuel standard stems from the 1994 NAS study (Ref. 8). The NAS recommended that "options for long-term disposition of weapons plutonium should seek to meet a 'spent fuel standard' - that is, to make this plutonium roughly as inaccessible for weapons use as the much larger and growing stock of plutonium in civilian spent fuel." The NAS and DOE have recognized that high levels of radiation are the primary barrier to diversion of plutonium in spent fuel and that this barrier decays over time. The NAS stated that "long-term options will be needed to reduce the proliferation risks posed by the entire global stock of plutonium, particularly as the radioactivity of spent fuel decays," and that "options for reducing these risks include placement of spent fuel in geologic repositories, or pursuit of fission options that would burn existing plutonium stocks nearly completely."

Without performing proper analyses, the DOE has determined that geologic disposal of the waste forms resulting from the alternatives evaluated in the Programmatic EIS will provide the necessary long-term safeguards. In justifying the spent fuel standard, the DOE states in Reference 7 that, "there is a path forward established by the Nuclear Waste Policy Act (of 1982) for disposal of spent fuel in a mined geologic repository, where geologic barriers will reduce the reliance on institutional controls." This conclusion is flawed for the following reasons: 17/12.00.00

> There is no consensus among experts that isolation of spent fuel (or immobilized plutonium) in a geologic repository would provide adequate long-term safeguards. It is important to realize that the NAS study (Ref. 8) makes no judgements and draws no conclusions regarding safeguards provided by geologic isolation. According to the Yucca Mountain Total System Performance Assessment (Ref. 15) and to the 1995 NAS report

M-132

12 00 00 Comment Number 17

The Pu waste forms being considered for disposal in an NWPA-HLW repository meet the Spent Fuel Standard, and therefore, pose no greater safeguards risk than the disposal of commercial spent nuclear fuel. Further, these materials are classified as CAT IV E, and will be subject to the same safeguard requirements as commercial spent nuclear fuel and defense high-level waste (DHLW).

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 32 OF 39

(Ref. 9), the eventual loss of institutional controls and human intrusion is considered to be a credible scenario for assessing long-term performance of a repository. An International Atomic Energy Agency (IAEA) advisory group concluded (Ref. 16) that LWR spent fuel "does not qualify as being irrecoverable at any point prior to, or following, placement in a geologic formation commonly described as a 'permanent repository,' and that safeguards should not be terminated on spent fuel." In a recent report (Ref. 17), the U.S. Congress Office of Technology Assessment (OTA) expressed "concerns about leaving plutonium in a repository that might be mined sometime in the future for the purpose of making weapons." This same concern was raised recently by an American Nuclear Society (ANS) Special Panel on Protection and Management of Plutonium (Ref. 18). During a presentation at a recent DOE workshop (Ref. 19), Peterson concluded that "geologic repositories will provide attractive sources of fissile material for nuclear explosives for roughly 200,000 years." These concerns raised independently by NAS, IAEA, OTA, ANS, and others provide strong justification for developing a disposal strategy in which fissile materials are destroyed before geologic disposal, since safeguards and institutional controls cannot be guaranteed for tens of thousands of years.

Even if it were determined that geologic disposal does provide adequate long-term safeguards, there is currently no permanent repository for spent fuel, and there is the distinct possibility that a repository will not be available for many decades. The political controversy associated with the Yucca Mountain repository project has slowed progress considerably. After spending more than $2 billion, there has still been no determination of whether the site is acceptable for disposal of commercial spent fuel. In the screening report (Ref. 7), the DOE acknowledges "the tremendous cost and time being taken to evaluate the suitability of Yucca Mountain as a mined geologic high-level waste repository."

Mixed-oxide (MOX) spent fuel from an plutonium disposition LWR would be significantly more attractive for diversion than commercial LWR spent fuel, particularly after the radiation field has decayed to lower levels. According to the 1993 DOE Plutonium Disposition Study (Ref. 20), a plutonium disposition LWR MOX spent fuel assembly would contain up to 30 kg of plutonium. This is enough plutonium to manufacture up to 4 weapons. For comparison, a typical commercial LWR spent fuel assembly would contain about 3.5 kg of plutonium of similar quality. A GT-MHR spent fuel element would contain less than 0.25 kg of much lower quality plutonium. In addition to increased diversion risks, the high plutonium content of plutonium disposition LWR MOX spent fuel would have a negative impact on the design of a spent fuel canister and repository loading strategies. Additional processing of MOX spent fuel may be required to lower the plutonium density.

Another issue associated with unprocessed LWR spent fuel as a permanent waste form is poor long-term containment provided by metal-clad fuel rods within metallic canisters. According to the Reference 15 performance assessment, a large fraction of LWR spent fuel would become

exposed within several hundred to several thousand years because of the expected failure of Zircaloy cladding and corrosion of metallic canisters, and the only remaining barrier for release to the accessible environment would then be the surrounding geologic media. The effectiveness of this barrier for long time periods is uncertain and could be compromised by unforeseen events, including climatic changes and increased seismic activity. In testimony before the House Commerce Subcommittee on Energy and Power on June 30, 1995, John Cantlon, Chairman of the Nuclear Waste Technical Review Board (NWTRB), stated that the NWTRB "has repeatedly urged the DOE to develop a robust, long-lived waste package that will work together with other engineered barriers and the geology at the site to provide long-term isolation of the radioactive waste from the accessible environment." Cantlon stated also that "the use of such waste packages can help improve confidence in the long-term performance of the repository and thus facilitate licensing of the facility." Other experts on disposal of high-level radioactive waste have stated (Ref. 21) that "any strategy of isolation should emphasize the near-field containment of radionuclides, a function primarily of waste form or 'waste package' performance" and that "strategies that rely solely on long travel times, dispersal, or dilution, implicitly presume release and movement of radionuclides." In a recent report (Ref. 22), the NAS concluded that the most harmful releases of radionuclides from a geologic repository could occur well after 10,000 years, which further underscores the need to provide effective near-field containment of radionuclides for geologic time periods. Other potential benefits of superior near-field containment are less required geological characterization of the candidate repository site and greater likelihood that a given site would be found acceptable.

Final waste form characteristics (and not just near-term diversion resistance) will determine the overall schedule for achieving effective disposition of plutonium. Plutonium disposition using deep-burn reactors like the GT-MHR could satisfy long-term safeguards requirements without relying on the availability of a geologic repository or the determination that the repository would provide the needed long-term safeguards. This is a very significant advantage for deep-burn reactors that has been overlooked during the DOE screening process. GT-MHR spent fuel would be a highly stable and highly diversion resistant waste form during potentially long-term storage and after permanent disposal. If future generations could respond to the DOE questionnaire, they would undoubtedly rate final waste form characteristics as the most important criterion for evaluating high-level radioactive waste forms, including those generated from disposition of surplus plutonium.

Final waste form characteristics and long-term environmental impacts should be given a high priority and careful evaluation when evaluating technologies for plutonium disposition. Advanced technologies that produce clearly superior permanent waste forms and have the potential to eliminate long-term, high-consequence environmental impact scenarios should be evaluated as part of the Programmatic EIS, particularly if the schedules for implementing these technologies are not significantly longer than those for more established technologies and if the potential for strong international collaboration exists. The GT-MHR would clearly meet these conditions.

16/01.05.00 cont.

M-132

GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 34 OF 39

Use of Borosilicate Glass for Vitrification

The vitrification alternative proposed in the draft PEIS would involve manufacturing borosilicate glass logs containing plutonium and high-level waste. Recent evaluations have raised significant issues that may preclude borosilicate glass as a host phase for immobilization of plutonium. These issues include potentially poor long-term durability in a geologic repository and long term irradiation effects. These issues received considerable attention during a recent DOE Plutonium Stabilization and Immobilization Workshop in Washington, DC (December 12-14, 1995). Since weapons grade plutonium consists mostly of the fissile isotope plutonium-239, with a half-life of about 24,000 years, the time over which the waste remains highly radiotoxic would likely exceed the expected lifetime of the glass. Scientists at Argonne National Laboratory have been developing a more durable glass for plutonium immobilization (Ref. 23). 18/05.01.08

DOE should acknowledge the potential problems with borosilicate glass and evaluate alternative glass forms during preparation of the EIS. 18/05.01.08 cont.

Viability of Electrometallurgical Treatment

According to the draft Programmatic EIS, the DOE will consider electrometallurgical treatment as an option for plutonium disposition. Electrometallurgical treatment was derived from pyroprocessing technology developed for reprocessing liquid metal reactor spent fuel. In its 1995 report (Ref. 9), the NAS evaluated pyroprocessing as an option for plutonium disposition. The NAS determined that pryroprocessing has several disadvantages that "effectively rule it out as a serious competitor for the near-term plutonium disposition mission." The NAS raised concerns with regard to the maturity of the technology, the size of the facility required to complete the disposition mission, and suitability of the final waste form for permanent disposal. In light of this evaluation by the NAS, the DOE should provide stronger justification for continuing to evaluate electrometallurgical treatment as a viable option for plutonium disposition. 19/05.03.08

Coated-Particle Waste Form for Plutonium Immobilization

Coated particles were once considered by the DOE as an alternative waste form for immobilization of high-level waste, and research programs were conducted at Pacific Northwest Laboratory and Oak Ridge National Laboratory (ORNL) in the early 1980s (e.g., Refs. 10 through 12). The feasibility of coating high-level waste was established at ORNL, and coated particles were judged to have by far the best performance potential of the candidate alternative waste forms. DOE should evaluate the coated-particle waste form for plutonium immobilization as part of the EIS process. 20/14.00.00

Environmental Impacts of the CANDU Reactor Option

While the Programmatic EIS discusses a full spectrum of environmental impacts of using an existing light water reactor for plutonium disposition, several of the similar environmental impacts for use of existing CANDU reactors (such as those at the Ontario Hydro Bruce-A

M-132

05 01 08 **Comment Number 18**

Alternative forms were evaluated before issuing the Draft PEIS. These results are reported in the document (available in DOE Public Reading Rooms): *Screening of Alternative Immobilization Candidates for Disposition of Surplus Fissile Materials*, February 9, 1996 (UCRL-ID 118819 [L-20790-1]).

05 03 08 **Comment Number 19**

Electrometallurgical Treatment was considered a reasonable alternative after completion of the screening process and scoping for the PEIS. The National Research Council recommended successful demonstration of the electrometallurgical treatment process prior to implementation. Upon making the decision on disposition technologies, DOE will demonstrate these technologies.

14 00 00 **Comment Number 20**

During the screening of alternatives for inclusion in the PEIS, various immobilization forms were considered. The decision was made to include immobilization in ceramic and glass forms. The specific ceramic form was not identified. Research and development (R&D) is both on-going and planned to support the disposition alternative(s), which would include pilot facilities for processes (such as ceramic coated particles) and materials, as necessary. Decisions on disposition of weapons-usable fissile materials will be based upon environmental analyses, technical and economic studies, national policy considerations, and public input.

Nuclear Generating Station, located on Lake Huron about 300 km (186 miles) northeast of Detroit) are listed in the document as not applicable. Examples include normal radiological impacts, hazardous chemical impacts, and facility accidents. The Programmatic EIS limits its evaluation of the environmental impacts from these sources for all alternatives to a radius of 80 km (50 miles) from the site boundary. The basis for limiting the evaluation to this radius is not presented. It is noteworthy, however, that no such limit is placed upon the evaluation of the environmental impacts from these sources in other Programmatic Environmental Impact Statements such as the Programmatic EIS for Tritium Supply and Recycle.

In effect, DOE has assumed that the environmental impacts from these sources for the CANDU reactor option somehow stop at the U.S./Canadian border and do not affect U.S. citizens living near the plant. This is obviously unrealistic, and DOE should include a full assessment of the environmental impacts of the CANDU reactor option in the final Programmatic EIS. 21/06.05.08

M-132

06 05 08 Comment Number 21

The environmental impacts in foreign nations are not addressed under NEPA. However, if the CANDU Reactor Alternative was selected, an assessment of environmental impacts would be accomplished pursuant to Canadian Federal and Provincial law. Further, the ROI used consistently for analysis of this PEIS for sites and technology, includes an 80-kilometer (km) (50-mile [mi]) radius. The distance from the U.S. border to the Bruce-A-Generating Station is greater than the distance for analysis.

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GENERAL ATOMICS, SAN DIEGO, CA,
A. J. NEYLAN
PAGE 38 OF 39

Relative Importance:	Theft / Diversion	Retrieval / Reuse	Technical Viability	ES&H	Cost	Time	Internat'l Influence	Public / Institutional	Additional Benefits	
Very Important	124	76	104	101	35	54	57	42	49	
Moderate	15	33	36	34	60	49	47	68	39	
Less Important	7	23	2	10	42	32	36	40	40	
Inappropriate	1	15	0	1	9	-10	5	5	16	

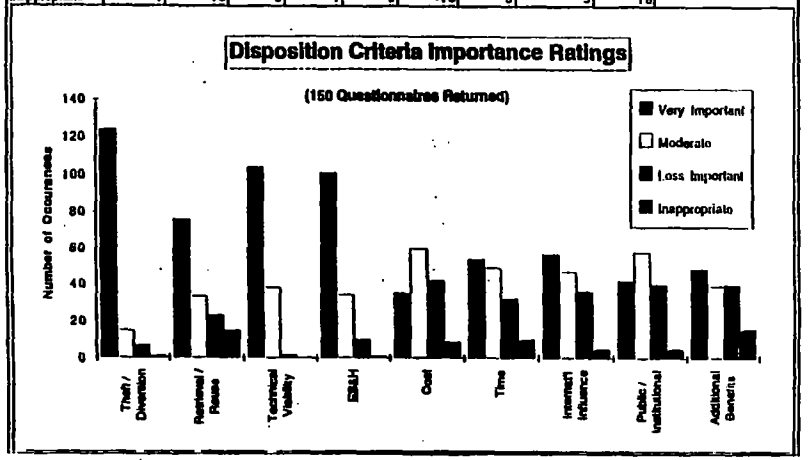

FIGURE 1 (FROM DOE/MD-0002)

M-132

Rank:	Theft / Diversion	Retrieval / Reuse	Technical Viability	ES&H	Cost	Time	Internat'l Influence	Public / Institut'l	Additional Benefits		
1	34	12	12	29	3	7	8	7	8		
2	33	14	20	22	7	8	5	7	2		
3	21	22	27	18	6	6	3	5	9		
4	10	9	27	23	8	13	16	7	5		
5	10	9	20	7	16	16	11	12	17		
6	3	16	5	10	22	15	19	16	11		
7	6	11	5	9	14	23	21	23	5		
8	2	9	2	3	21	19	18	27	17		
9	0	15	0	1	18	11	17	15	41		

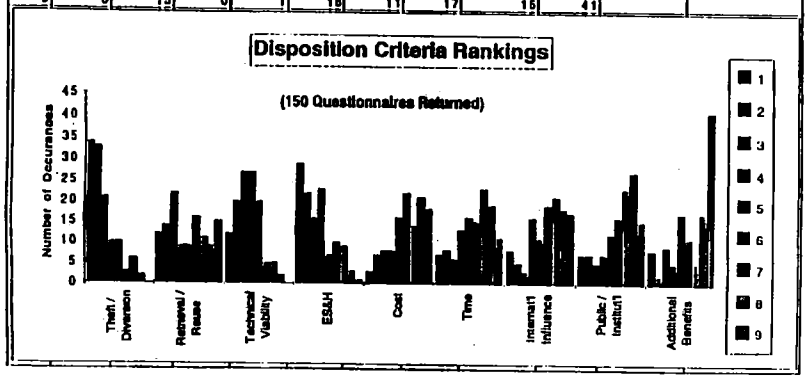

FIGURE 2 (FROM DOE/MD-0002)

M-132