WSRC-RP-89-33

COMPARISON OF ALTERNATIVE NPR FUEL CYCLES (U)

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APRIL 1989

Unclassified
Deriviative
Classifier:____

ABSTRACT

It is likely that the proposals for the new heavy water production reactor will include at least one design incorporating a low-enriched uranium (LEU) fuel cycle while other designs will incorporate the traditional high enriched uranium (HEU) fuel. The LEU option would offer small advanatages in reactor safety. On the other hand, as shown in this evaluation, using LEU rather than HEU in the new heavy water reactor would decrease tritium production by 25% for comparable power-level reactors and would increase the annual throughput of total uranium about 10-fold. This would increase capital cost by $275 million and annual operating costs by $27 million, and would require several modifications to fuel fabrication, fuel reprocessing, and waste management facilities. Furthermore, the estimated four-fold increase in high-level waste from the LEU fuel cycle would run counter to DOE's long range goal of waste minimization.

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INTRODUCTION

DOE expects that responses to the request for proposal to build the new heavy water reactor (HWR) will include a proposal to fuel the reactor with uranium that contains less than 10% U-235 (designated low enriched uranium or LEU) as an alternative to the traditional high enriched uranium (HEU) fuel cycle used in existing HWR's at the Savannah River Plant (SRP). To evaluate the LEU option requires knowledge of the reactor operating parameters and their effect on the nuclear materials processsing infrastructure. This report compares the fuel cycle characteristics of a possible LEU-fueled HWR with those of the HEU version and discusses the effects of an LEU fuel cycle on cost and on the fuel fabrication and reprocessing infrastructure at the Savannah River Plant.

SUMMARY

Key attributes of an LEU-fueled HWR relative to an HEU-fueled reactor are summarized in Table 1. An LEU-fueled reactor would have the advantages of better perceived safety and, possibly, facilitated acceptance of the safety analysis because the low enrichment essentially precludes having an already very low probability re-criticality accident. SRL studies indicate that the actual safety advantage would be quite small.

Table 1. LEU Effect on HWR Reactor

- Increased perception of safety
- Easier safety analysis and facilitated acceptance of SAR
- About 25% decrease in tritium productivity (grams produced per reactor MWD)
- $ 275 million reactor capital cost increase for same production rate
- $ 5 million/yr operating cost increase for same production rate
- $ 27 million/yr waste processing and waste disposal cost increase*
- Ten-fold increase in total U mass in charge
- Increased size of fuel assemblies and reactor tank*
- ~75% more fuel and target components per year*
- ~ 200 MT increase in D_2O needed which would cost an additional $40-50 million if purchased.
- New fuel and new billet fabrication facilities*
- Additional dissolving, extraction, waste evaporation and uranium solidification facilities (added cost not evaluated)*
- About four fold increase in high-level waste volume*
- Possible requirement for new waste tanks costing $ 28 to 56 million*
- Fuel grade plutonium by-product

For what appears to be a small advantage, an LEU fuel cycle would have several disadvantages relative to an HEU fuel cycle. Use of LEU in the NPR would increase the total mass of uranium in each reactor core by a factor of 10 over that of the same design using HEU. This increases the size of the fuel assemblies and of the reactor tank and makes the use of cermet fuel necessary to achieve higher reactor productivity. The large

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* Several options exist for fuel type and reactor size with LEU. These items refer to the only likely combination; a 3300 MW reactor using cermet fuel. Other combinations can vary greatly in either degree or kind of effect.

U-238 content of the fuel decreases tritium productivity (gms tritium per MWD) at least 25% and increases the plutonium produced. Hence, reprocessing the fuel to recover both the U-235 and the plutonium is required. (The plutonium recovered would be fuel grade and not suitable for weapons use without isotopic separation.) The number of fuel components required per year would also increase 75 to 130% over operation with highly enriched uranium. The larger reactor with more fuel assemblies would increase the need for D_2O and may require early shutdown of existing reactors or purchase of new D_2O. The greater number of larger assemblies would also require installation of additional reprocessing equipment and would increase the amount of aluminum to be dissolved and processed as waste by a factor of up to four. This would be counter to DOE's long range goal of waste minimization [1].

The LEU reactor would also produce fuel grade plutonium equivalent to about one-fourth of the tritium produced. This would be an advantage if the plutonium is needed for the weapons program and if the planned Special Isotope Separations (SIS) facility is available to isotopicly convert the plutonium to weapon-grade material. Fuel grade plutonium production might be a disadvantage in that additional equipment would be needed to separate the plutonium at SRP and that storage and eventual disposal might be required.

DISCUSSION

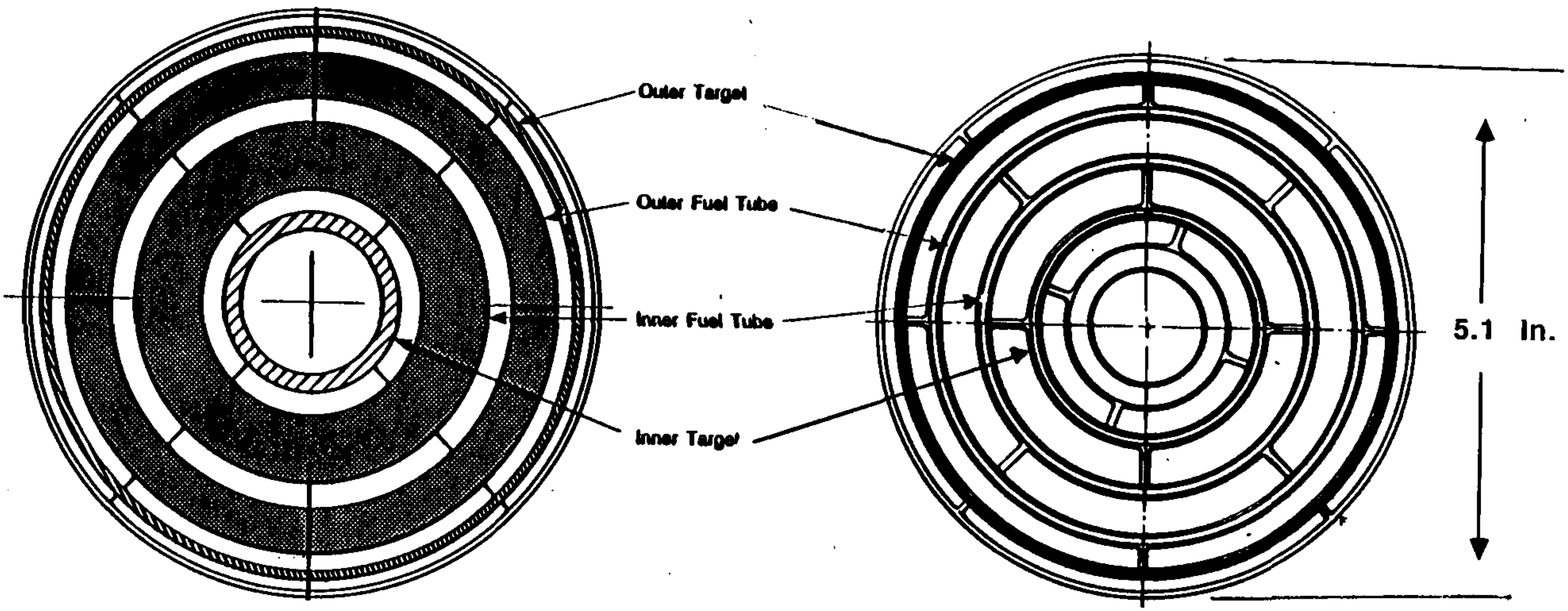
Assembly Description

The fuel assembly that would likely be used in the heavy water NPR if LEU were the fuel would be slightly larger than the Mark 22 used in existing reactors with thicker fuel tubes[2] (Table A1 in Appendix) and would be fabricated by powder metallurgy because of it's high uranium content.

The size and thickness of the individual tubes and fuel assemblies in a given charge design are determined by the amount of lithium or uranium to be contained and by physical parameters that optimize the operation of the reactor (operational coefficients, cycle length, and neutron productivity). The desired U-235 content of a reactor core (and therefore in each fuel assembly) is determined mostly by production considerations. Within limits, production tends to increase when the total U-235 is increased to support a large lithium target loading and a long cycle length. This results in optimum fuel cycle lengths of 6 to 9 months which, when combined with required maintenance outage, results in the irradiation of 1 to 1.5 fuel charges per reactor each year. This optimum is achieved when the reactor contains about 300 gms of U-235 in each foot of fuel length.

The total amount of uranium that can be physically contained in a fuel assembly depends on the isotopic assay of the uranium. An assembly with 300 gm/ft of uranium enriched to 93% U-235 contains only 322 gm/ft of total uranium with very little of the undesirable uranium isotopes. However, if the assembly is made of 8% enriched uranium, there is 11-times more undesired isotopes than the desired U-235. Therefore, putting the same 300 gm/ft of U-235 into an assembly will result in a total uranium content 11 times that of the 93% assembly. This additional uranium can be physically accommodated by making the fuel assembly larger, making each fuel tube thicker, and/or by increasing the ratio of uranium to aluminum in the fuel core.

FIG. 1 COMPARISON OF NPR ASSEMBLIES FOR TRITIUM PRODUCTION



8% U-235 ASSEMBLY

Typical
Wt./Assembly, Kg:
U-235 ....2.6
Total U.........33.0

80%-93% U-235 ASSEMBLY

Typical
Wt./Assembly, Kg:
U_235 ....3.7
Total U 4.7

In one HWR concept[3], the fuel assembly already has been increased to about a 5-in. diameter to ensure negative temperature coefficients. If the fuel tubes are also increased to their maximum thickness (Figure 1), the tubes still cannot contain the necessary increase in uranium using the current metallurgical casting limits on U-Al ratios in extruded fuel[4]. At the 35-weight percent uranium limit, the thicker fuel tubes would accommodate only 177 g/ft of U-235 (Table 2). Therefore, an HWR using LEU fuel must also increase the ratio of uranium to aluminum in the fuel tubes to achieve an economical fuel weight.

The most likely method of increasing U-Al ratios is to use fuel tubes fabricated by the powder metallurgy process; i.e. uranium-oxide aluminum cermet fuel. This technology can increase the allowable uranium loading in the fuel core to >50% uranium by weight, has had substantial development and testing, and is planned for the existing reactors[1]. The cermet fuel would allow a core loading of about 270 g/ft of U-235 at a reasonable composition limit. Higher loadings should be feasible with development.

Table 2. Maximum U-235 Loading With 8% U-235

Fuel Form	Max. U-235* @ 8%, g/ft	Comment
U-Al Extrusion	177	35 Wt. % Total U
U_3O_8-Al Cermet	270	52 Wt. % Total U
U Metal	>300	Very Thin Casting
U Microspheres In Al	<200**	Process Not Developed

Another alternative is the use of uranium metal cores. This increases the uranium in the fuel assembly core to 100% by weight and allows U-235 loadings of over 300 g/ft. Irradiation of metal cores has been demonstrated at SRP. The Mark 15 consisted of short lengths of metal cores that were canned in aluminum and stacked into the fuel assembly. The Mark 15 used an enrichment of 1.1 % U-235.

At 8% enrichment the metal cores would be only about 0.1 inch thick. At this thickness the problems of controlling core uniformity and ovalness would be significant as would obtaining and processing cans with such small annuli. A development and irradiation program would be required.

Past irradiation tests[5] have indicated that metal cores suffer excessive radiation-induced distortion at the exposures of 30,000 MWD/tonne that would normally occur in the fuel in tritium producing cores. If the fuel were limited to exposures of 10,000 MWD/tonne, it would probably be sufficiently stable at the irradiation temperatures of less

* This report assumes 8% fuel enrichment, reactor and assembly design, and production capabilities presented by Westinghouse to DOE in the NPR concept selection process (Reference 6). These parameters have not been independently verified by SRL.

** Very preliminary estimate based on retaining Al based technology than 400 °C, but only 10% of the U-235 in the fuel would be burned. At these low exposures, 3 to 4 fuel cores would be irradiated every year requiring a very large pipeline of 8% enriched uranium (see **U-235 Supply For NPR**).

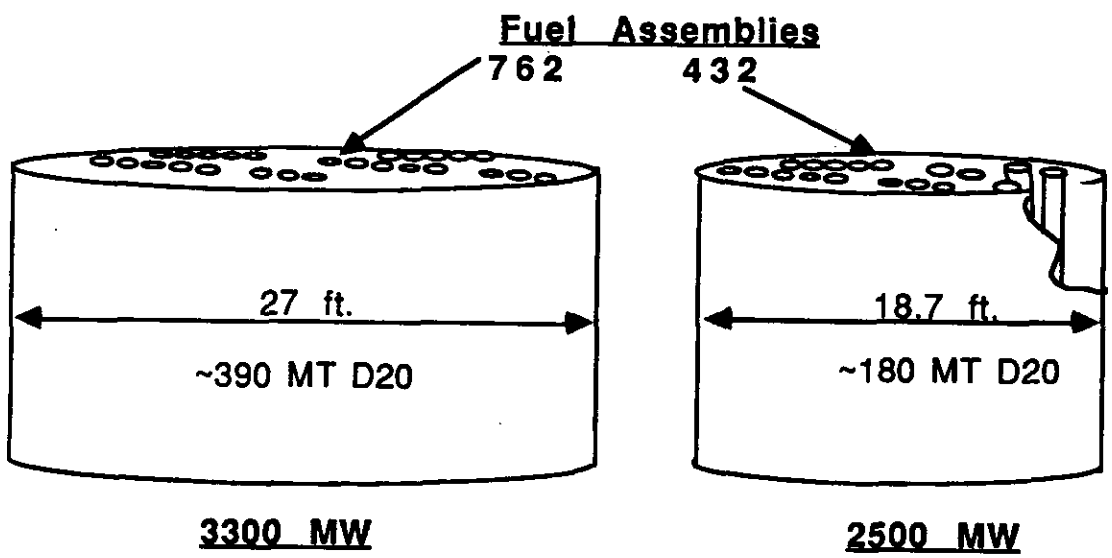
A new fuel type comprising uranium-oxide microspheres encapsulated in layers of carbide, dispersed in an Al matrix, is currently under study for SRP fuel. This fuel type has potential advantages in the containment of fission products in the event of an accident. The maximum fuel density that can be achieved may be much less than in current extruded cores. If this is true, the productivity of a reactor would be significantly lower at the fuel loading obtained with LEU when using microspheres than with HEU fuel.

Reactor Size

The size of a reactor affects the capacity for fuel, production rate, capital cost, amount of D_2O required, reactor power level and the annual operating cost. It is assumed that any LEU-fueled reactor would have an annual average power of at least 3300 MW (compared to 2500 MW for the existing reactors) to achieve the goal tritium production rate.

Reactor power is most easily increased by increasing the size of the reactor tank to contain more fuel assemblies (Figure 2).

Figure 2. Variation In Reactor Size With Power Level



It should be possible to extend the design of the existing reactors to 5000 MW or more. However, one of the basic reasons for selecting the HWR concept as the NPR was the large assurance of successful implementation that comes with using a proven design. At some point, increases in reactor size would seriously erode this assurance. The original (1985) NPR proposals by SRL (an HEU fueled HWR) and the design developed by the DuPont Engineering Department and Bechtel was for 3300 MW[7]. The Westinghouse proposal for an LEU fueled HWR considered by the Energy Research Advisory Board (ERAB) Panel was for 3300 MW. Although a 3300 MW reactor is considerably larger than the existing reactors it seems to be a reasonable size to assume for evaluations.

Cost

The 3300 MW reactor would need a larger tank which would increase the reactor capital cost about $275 million above the cost for a 2500 MW reactor[8]. The larger throughput of components and the added pumping power for the larger reactor would increase annual operating cost by about $5 million[9] and waste processing costs by about $27 million (see **Effect on SRP Operating Facilities**). New waste tanks costing $56 to 84 million may also be required.

Production

Tritium is produced in the NPR through the absorption of neutrons in the lithium targets. The neutrons will also be absorbed nonproductively in all other isotopes present, including isotopes of uranium other than U-235. In charges operating with HEU, the amount of neutron absorption in the small amount of U isotopes other than U-235 typically results in less than 1% tritium production loss. The large amount of U-238 in cores using LEU (Figure 3) significantly increases the nonproductive (non-tritium producing) absorptions of neutrons. With an 8% enrichment, about 25% of potential tritium production is lost to absorptions in uranium.

The production in tritium producing cores with long cycles is almost directly proportional to power. A 3300 MW reactor has the potential to produce ~30% more than a 2500 MW reactor. A greater reactor power can be used to offset the lower tritium productivity that results from using LEU. Westinghouse indicated[10] that, because of the absorptions in uranium, a 3300 MW LEU reactor would produce the same amount of tritium as a 2500 MW HEU reactor.

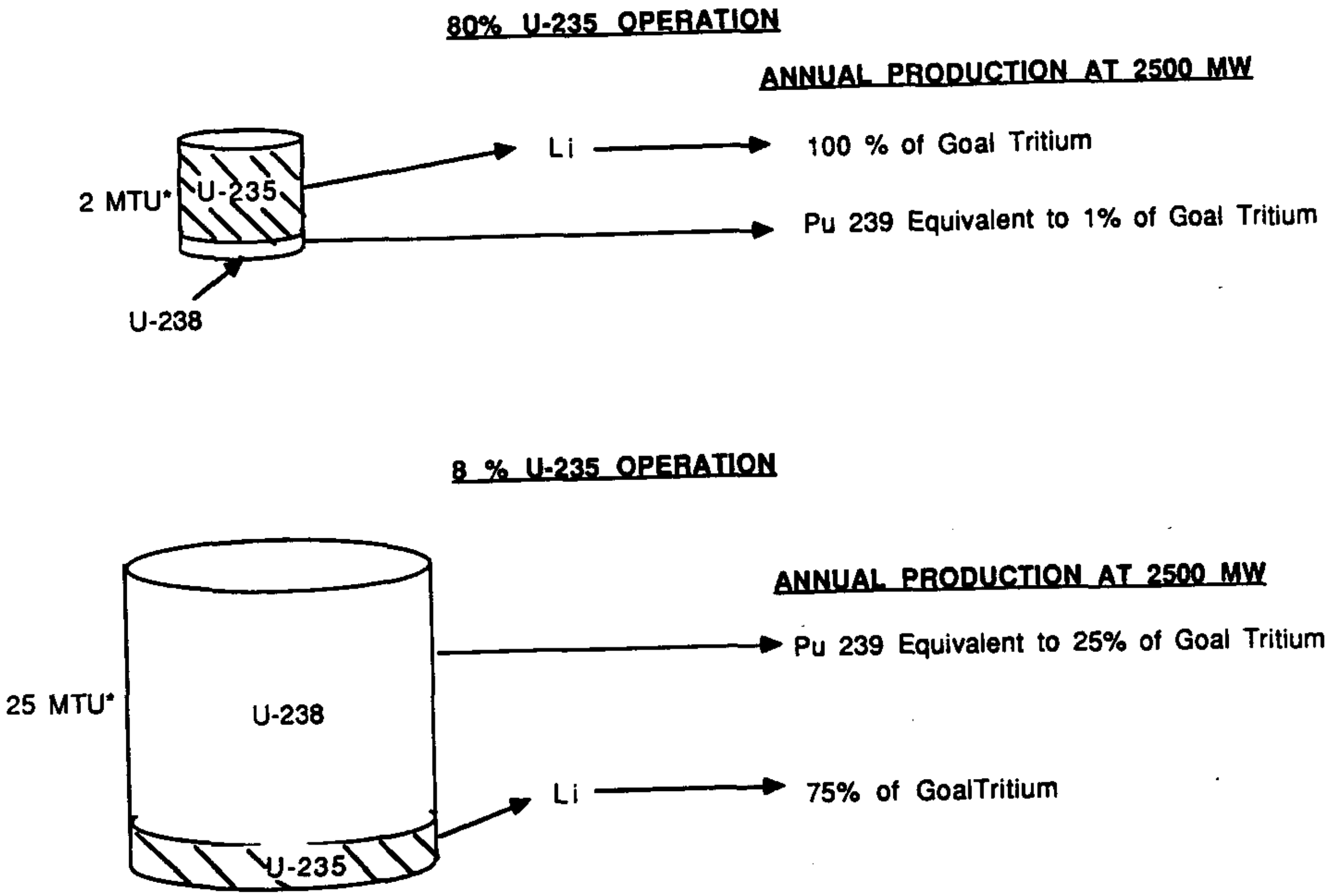
Most of the neutrons absorbed in U-238 produce plutonium. Detailed production calculations have not been made, but an estimate shows that the composition of the plutonium produced depends on the cycle exposure and U-235 loading (Table 3).

Table 3. Estimated PU Composition in Discharged LEU Fuel[11]

	U Metal Fuel	Extruded Fuel	Cermet Fuel
Cycle length, days	75*	195	241
Assembly Exposure, MWD/ft	25*	65	80
Pu-238, % of Total Pu	0.1	0.2	0.2
Pu-240, % of Total Pu	>4	13	11
Pu-241, % of Total Pu	1	5	5

* Limited by irradiation-induced swelling

Fig. 3 COMPARISON OF NEUTRON ECONOMIES



* MTU = METRIC TONS OF URANIUM

In the most practical cases for tritium production, the Pu-238, 240, and 241 contents of the plutonium would be too high for direct use in weapons. The plutonium could, however, be recovered and saved for possible use as future feed stock for isotopic enrichment in the SIS Facility. That facility, as planned[1], has sufficient capacity to consume all of its existing feed in 8 to 10 years and could, if there is a need, convert fuel-grade plutonium from NPR fuel into weapon-grade plutonium. Recovery of the fuel grade plutonium during fuel reprocessing will require installation of new equipment in the canyon at SRP (see **Effect on SRP Operating Facilities**). If there is no future need for additional plutonium, the plutonium by-product from tritium production in a LEU-fueled HWR would become a liability that must be stored and/or disposed of.

D_2O

The NPR with separate moderator and cooling systems, upflow cooling, pressurizer tanks, added emergency cooling, etc. will require more D_2O than the existing reactors (Table 4). Higher power reactors will also require more D_2O because of the larger reactor tank:

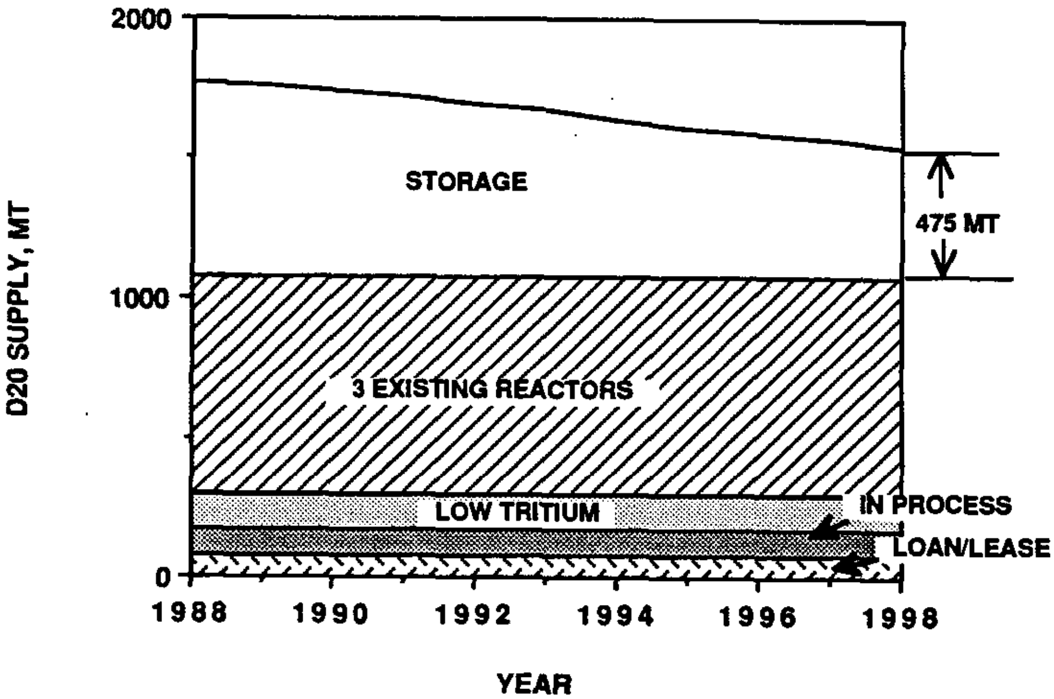
Table 4. D_2O Requirements for NPR Designs

Design	Enrichment	D_2O Needed, MT**
Existing Reactors	HEU	250
SRP NPR @ 2500 MW	LEU	460[12]
SRP NPR @ 3300 MW	"	670
EBASCO NPR @ 2400 MW	"	870[10]
Westinghouse NPR @ 3300 MW	"	?

The D_2O remaining in SRP'S inventory[13] at the time the NPR starts up in 1998 is estimated to be about 500 MT more than that needed to fill three existing reactors (Figure 4). This incremental amount is less than that needed for the preliminary designs of several proposed HWR's. The supply could be stretched by shutting down existing reactors before the NPR comes on line, by decreasing the in-process inventory (~80 MT), by recalling material on loan or lease (~75 MT), or by buying new D_2O. DOE's current plan[1] is to shut down one existing reactor at the time the NPR starts up and to shut down the remaining existing reactors as the NPR becomes fully operational. Excessive D_2O requirements for the NPR could cut DOE's options for operating the existing reactors to meet tritium demands prior to NPR startup. If it becomes necessary to purchase 200 MT of D_2O, the cost would probably be about $250/kg[14] for a total cost of $50 million.

** All NPR estimates are for preliminary designs which have probably not been studied to minimize D_2O use.

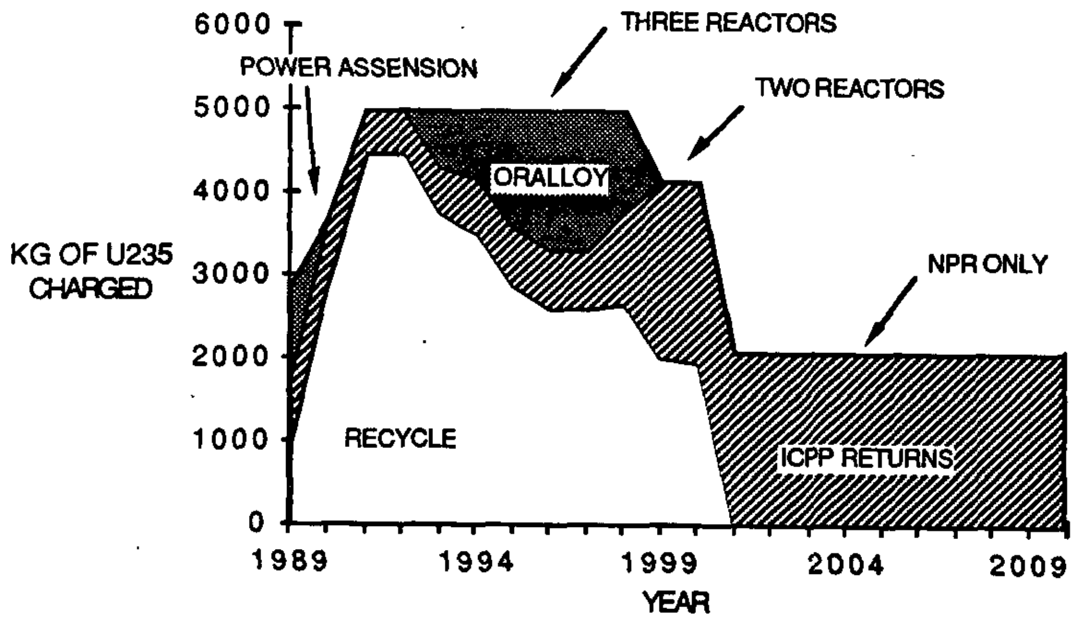
Figure 4. Projected Heavy Water Supply



U-235 Supply for NPR

A new HEU-fueled HWR would use HEU recovered from the naval reactor spent fuel (~80% U-235) recovered in the Idaho Chemical Processing Plant and HEU from the existing SRP stockpile of previously irradiated fuel (50 to 60% U-235). This would be supplemented as necessary with 93% U-235 (oralloy) from the DOE enrichment facilities. The projected supply of naval fuel returns is sufficient to fuel a new HWR (once its pipe line is established) without using oralloy (Figure 5) if the existing reactors are shut down on schedule. Operating the existing reactors at 95% power and the NPR startup will require ~10,300 Kg of oralloy between 1988 and 2010.

Figure 5. U-235 Use In SRP Reactors



DOE is also planning to build a modular high temperature gas cooled (MHTGR) NPR. This reactor might also use the naval fuel HEU stock. If the four HTGR modules start up on schedule and if they use the same fuel as the HWRs (rather than oralloy as has been proposed[10]), the only effect is a small increase in oralloy use to create the additional pipeline for the HTGR and the use of additional SRP recycle fuel (Figure 6).

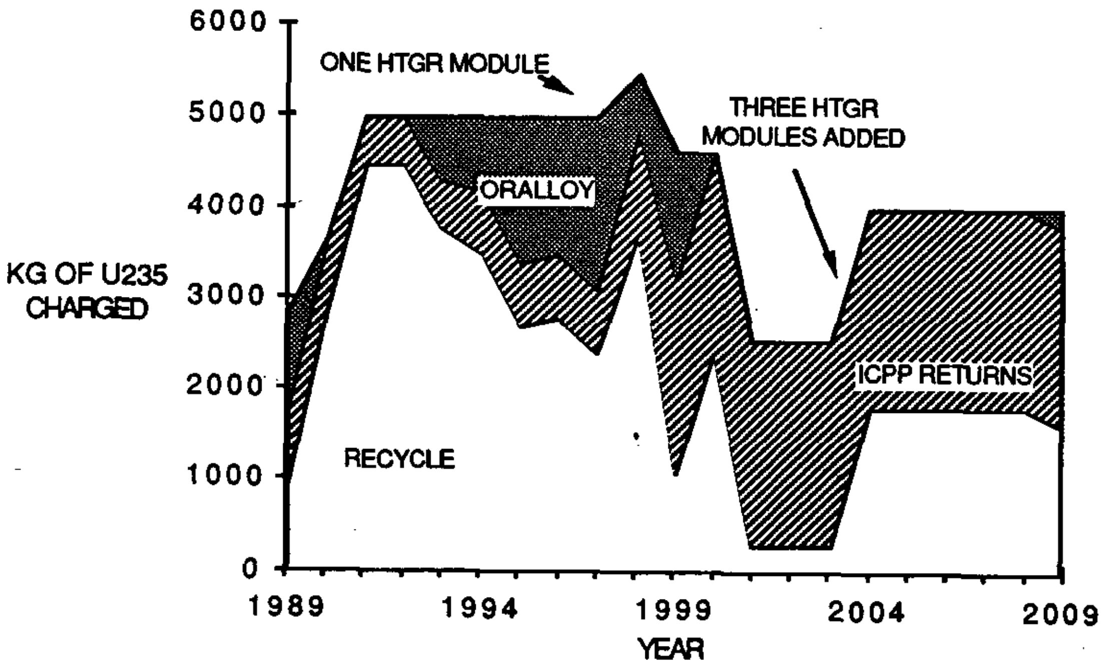
Naval reactor returns and the SRP stockpile could also be used to fuel LEU charges by blending with depleted or natural uranium and/or with the existing N-Reactor LEU stockpile. (Of course the act of blending 80% enriched uranium down to 8% enrichment would lose much of the separative work contained in the higher enriched material.) The U-235 used in either LEU cermet or U-Al extruded fuel would be about the same as with HEU fuel except that a small additional amount of oralloy is needed at first to create a separate pipeline of 8% enriched material (Table 5).

Table 5. NPR Oralloy Use

Charges Operating	Oralloy Used 1989 - 2010, Kg
HWR Fueled with HEU	10,300
HWR and HTGR Fueled with HEU	11,500
HWR Fueled with LEU and HTGR Fueled with HEU	
- Cermet or U-AL Fuel	12,000
- U Metal Fuel	43,200

If uranium metal charges are used and the exposure is limited to 10,000 MWD/tonne (as discussed on page 4), oralloy use is increased to over 40,000 Kg by the year 2010*. This large increase is caused by the larger pipeline needed when three to four cores are fabricated each year rather than a little more than one per year needed with the other fuel types. The high cost of a pipeline of this magnitude has prevented the use of the Mark 15 charges for plutonium production despite their 25% higher productivity. Because the burnup of the U-235 in the fuel is so small, recycle of the uranium metal would be necessary.

Figure 6. U-235 Sources With Two NPR's



Safety

The safety of a LEU-fueled HWR should be essentially comparable to that of an HEU-fueled HWR, except possibly for criticality considerations. An enrichment of 8% U-235 was selected by Westinghouse based on calculations which indicated that a low-enriched core was unlikely to experience a criticality during accidents in which the uranium in the core is redistributed; i.e. recriticality as a result of core melting. This accident has an extremely low probability ($<10^{-6}$) of occurring. However, during the forthcoming safety reviews, this "inherently safe" feature with LEU might be advantageous in the safety

* Because the oralloy use is so large, this material would probably be fabricated by drawing 8% material from the cascades. However, the calculation assumed blending with oralloy to allow a comparison to the other cases.

analysis because of the perception of increased safety and because the safety analysis could more easily show that re-criticality would not occur with a given design.

Preliminary investigations by SRL and Westinghouse show that re-criticality is a consideration only with core disruption. Westinghouse concluded[15] that "...analysis shows no challenge to containment integrity due to energetics...","...that the activity insertion rates limit re-criticality power excursions to benign energy releases..." but that "...issues on direct containment heating may be perturbed by re-criticality issues...". Bounding calculations by SRL[16] affirmed the low level of direct energy release; showing that the "...energy release from re-criticality (9,600 MJ) is less than the energy already contained in the molten fuel(17,000 MJ)...". They also showed that "...a direct containment heating event, precipitated by a dry re-criticality event, will generate pressures and temperatures only modestly larger than those generated by the adiabatic heating (from the fuel)." Furthermore, total containment heating in an HWR during core disruption with re-criticality is less than containment heating in an LWR without re-criticality.

Another potential safety issue is associated with cermet fuel which would probably be used in either LEU or HEU designs but which is not required for HEU. At issue is the potential for reaction between the uranium oxide and the aluminum metal. This issue arises only if fuel melting occurs. In that event, the energy added to the accident is small and only a fraction of the material would react. However, a study by SRL[3] shows that even if all of the U_3O_8 in the reactor were consumed by this reaction, the heat generated would be about equal to the heat absorbed in the melting of the Al in the fuel. SRL data also shows that no credible amounts of impurities should have a noticeable effect on either U_3O_8-Al reactions or the course of a severe accident in SRP reactors.

Effect on SRP Operating Facilities

100 Areas (Reactor Facilities)

The use of LEU would effect the reactor design (such as requiring a larger disassembly basin to handle the extra assemblies), but the new reactor would not be dependent on any of the existing 100 Area facilities.

200 Areas (Spent Fuel Processing)

Using LEU would have several significant effects on the H Canyon fuel reprocessing facilities. All of these could be solved by equipment modifications or new equipment. Several of the concepts result in material flows that exceed the current capacity of the equipment (Table 6) In all cases the processing time is over three times that required to process an existing charge, and would likely preclude extensive operation of the existing reactors at the same time as the NPR.

For the cermet concept, the capacity required for one reactor using LEU fuel closely matches the existing total capacity of most processes, although enhancement would be needed in waste evaporation and uranium solidification. To have additional capacity for processing other materials, such as research fuel, it would likely be necessary to install additional equipment in most of these process areas. The cost of these changes has not been evaluated.

Table 6. Time to Reprocess LEU Fuel

Process	Attainment Assumed	Days to Process One Reactor Per Year[17] Existing Reactor	New Production Reactor U Metal	UAL	Cermet
Dissolving	85	67	180	470*	260
Extraction	80	27	180	230	215
Waste Evaporation	70	51	960*	300*	315*
U Solidification	80	20	1450*	350*	430*

The LEU fuel would contain large amounts of Np-237 if recycle fuel is used in addition to the previously discussed large quantities of Pu-239. The H Area HM process can currently recover either Np or Pu, but not both, from the fuel in addition to uranium. A mixed Np-Pu product cannot be recovered because it is impossible to maintain simultaneously both Np and Pu in their extractable valence states. Recovery of both Np and Pu would therefore require installation of new primary extraction equipment.

300 Area (Fuel Fabrication)

The two LEU driver tubes (see Figure 1) would be heavier and thicker than any previously processed by the 300 Area equipment. New or modified extrusion equipment would be needed if the existing enriched fuel fabrication facility were used. However, it is anticipated that prior to NPR operation, a new powder metallurgy facility would be constructed to fabricate enriched cermet-type fuel for the existing reactors. In that event and if the NPR is to use LEU fuel, the powder metallurgy facility would be designed with several times the planned capacity to accommodate LEU fuel. The cost of this increased capacity has not been evaluated.

M, S, and Z Area (Waste Processing and Solidification)

Use of LEU in the NPR greatly increases the amount of Al to be dissolved and processed if either extruded or cermet cores are used. The volume of high level waste (HLW) generated at SRP is highly dependent on the fuel's Al content as well as on the amount of uranium. With cermet cores, the waste volume from LEU fuel would be about four times that of one existing reactor or a HEU NPR (Table 7). This volume increase would cause a $27 million per year increase in waste processing costs but would not strain the process capability. The cost increase would be greater with the other fuel concepts. The fission products to be processed depends on the annual reactor exposure; thus, processing increases of about 30% would occur with LEU fuel (relative to a HEU design) with all fuel forms due to the higher reactor power (see Table 7).

Handling the additional volume of waste may require one to three additional waste tanks at a cost of $28 million each. This requirement would have to be studied in detail and depends on many other operating assumptions.

* Required capacity approaches or exceeds that available

Table 7. Fission Product and Aluminum Throughput

Type Charge	Exposure KMWD/Yr	Aluminum Throughput MT/Yr	Waste Cost, $ Millions/Yr (17)(18) Processing At SRP	Canisters For Waste
Existing and Proposed HEU NPR	650	11	1	6
Metal	825	30	6	53
U-AL	890	77	5	45
Cermet	895	42	3	31

Tritium Processing

The fuel enrichment would have little or no effect on the target processing as long as the assemblies are designed to allow the lithium targets to remain in the reactor long enough to achieve tritium concentrations comparable to current values.

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APPENDIX A FUEL CYCLE PARAMETERS FOR LEU HWR

Table A1 Dimensions of Westinghouse Bechtel Assembly for 8% Enriched NPR Operations

Outer Taget	
Cladding o.d. (in)	4.793
Target o.d.	4.733
Target i.d.	4.701
Cladding i.d.	4.641
Outer Fuel	
Cladding o.d.	4.387
Fuel o.d.	4.327
Fuel i.d.	3.608
Cladding i.d.	3.548
Inner Fuel	
Cladding o.d.	3.124
Fuel o.d.	3.064
Fuel i.d.	2.055
Cladding i.d.	1.995
Inner Target	
Cladding o.d.	1.590
Target o.d.	1.530
Target i.d.	1.295
Cladding i.d.	1.235

Table A2 Core Parameters for Various NPR Fuel Options

	High Enriched	Low Enriched		
Fuel Composition	U-Al	U Metal	U-Al	Cermet
Fuel Enrichment, % U-235	80	8	8	8
Reactor Power, MW	2500	3300	3300	3300
No. of Fuel Assemblies	432	762	762	762
U-235 Burnup, %	40	10	36	40
Assy, Exposure, MWD/FT	100	25	65	80
Annual Exposure, KMWD	650	825	890	895
Cycle Length, Days	235	75	195	241
Cycles/Year	1.24	3.6	1.5	1.22
Assemblies/Year	535	2740	1140	930
Fuel Tubes/Assembly	2	2*	2	2
Target Tubes/Assembly	2	2	2	2
Fuel Loading, g U-235/Ft	300	300	177	270
Weight./Assy, gm				
U-235 Charged	3750	3750	2212.5	3375
Total U Charged	4688	46875	27656	42188
U-235 Discharged	2250	3375	1416	2025
Composition of Pu in Fuel,%				
Pu-240	11.4	4.4	13	11.4
Pu-241	6.8	0.8	5.2	4.9
Annual Al throughput, MT	9.9	24.6	74.8	40.3
Average Al, Kg/Tube	9	4	33	22

*Slug Columns

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Aiken South Carolina 29802

Dear Mr. Rollins:

COMPARISON OF ALTERNATIVE NPR FUEL CYCLES

SRP reactors have been using highly enriched uranium fuel (60-93% U-235) for production of both tritium and Pu-239. It is likely that the proposals for the new heavy water production reactor will include at least one design incorporating a low enriched uranium fuel cycle while other designs will incorporate the traditional high enriched uranium fuel. A study has been made to compare the production and economic impact of reducing the fuel enrichment of 8% U-235 for the NPR. Results of the comparison are provided in the attached report by F. D. King.

Please note that this study was performed prior to WSRC assuming management and operating responsibility for the Savannah River Site. All future interactions with potential bidders for the new heavy water production reactor design will be subject to WSRC policies and procedures to ensure full compliance with DOE orders on competitive procurements.

Very truly yours,

GA Krist

George A. Krist, Manager
Planning

FDK:jm