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From: Arjun Makhijani <arjun@ieer.org>
To: <TCJ@nrc.gov>
Date: 11/14/02 6:44PM
Subject: IEER comments on LES

Dear Mr. Johnson:

Please find a Microsoft Word document containing IEER's comments on the LES white papers. I request you to accept and respond to these comments even though they are a day late. I was travelling and have returned to my office from Minneapolis this afternoon. I had been there since Saturday.

Please acknowledge receipt of these comments.

Thank you very much.

Arjun Makhijani, Ph.D
President, Institute for Energy and Environmental Research
301-270-5500

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Comments of the Institute for Energy and Environmental Research to the Nuclear Regulatory Commission on White papers presented by LES (Louisiana Enrichment Services) regarding the proposed enrichment plant at Hartsville, Trousdale County, Tennessee

Arjun Makhijani and Annie Makhijani

14 November 2002
by e-mail TCJ@nrc.gov

Analysis of need and the no-action alternative

The need for the project must be assessed according to two primary criteria:

1. the market for enrichment services in light of existing supply as well as demand
2. national security considerations, including the current, projected, and desirable downblending of both Russian and US highly enriched uranium (HEU) for the purposes of fulfilling non—proliferation and disarmament commitments as well as for reducing the risks of nuclear diversion, especially in the aftermath of the tragic events of September 11, 2001.

However, the analysis by LES does not provide an analysis of either of these considerations. Rather it makes reference to "Congressional policy pronouncements" that there is an established need for a domestic source of uranium enrichment capacity. This is a completely insufficient basis for asserting the need for a project that will have a major impact on the supply of enrichment services as well as on national and global security.

LES must provide the documentation and analysis on the basis of which it is asserting the need for the project. If it is going to rely on congressional policy pronouncements, then the economic and technical basis of those pronouncements must be set forth in sufficient detail for an independent assessment of their validity to be made. There is no way in which the NRC or any other body can assess the soundness of LES's assertion unless such documentation and analysis is provided.

The current enrichment capacity as well as the existing commitments and projects to downblend surplus military HEU in Russia and the United States into LEU reactor fuel taken together indicate that there is no need for the LES project in the short- and medium-term

- There is enough LEU (Low Enriched Uranium) for about 6 years to fuel all the U.S. reactors at the current rates of consumption from the down-blending of the remaining 350 metric tons of Russian surplus HEU at Portsmouth Ohio by USEC (US Enrichment Corporation), assuming 1.5 percent enriched blendstock.1
- The down blending of the remaining 120 metric tons of US surplus LEU will provide fuel for the U.S. reactors for about 1.5 years at the current rate of consumption, assuming natural uranium blendstock.2

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1 In their 1995 book, *Fissile Materials in a Glass Darkly, Technical and Policy Aspects of the Disposition of Plutonium and Highly Enriched Uranium,* p.77, the authors calculated that the blending down of the surplus of Russian HEU of 500 metric tons (estimated by the Rand Corporation) could provide enough LEU to fuel all the U.S. reactors for almost 8 years.
2 In 1994 the DOE declassified the amount of HEU produced in the United States between 1945 and 1992 as being 994 metric tons In 1995, President Clinton declared 175 metric tons of HEU as surplus to defense needs. 155 metric tons of this surplus can be blended down to provide fuel for reactors and the rest that cannot be used as reactor fuel is slated as waste.

This means that a total of almost 8 years of U.S. demand for enrichment services is already in the pipeline due to the downloading of military HEU that has been declared surplus. The U.S. annual demand is 11 to 12 million SWUs per year. The downblending of military HEU is occurring at a slower rate than desirable for security reasons to prevent a huge surplus of LEU fuel on the market.

In addition, the United States Enrichment Corporation has an agreement with the U.S. DOE to keep the Paducah plant open until it brings a centrifuge plant on line. The separative work capacity of the Paducah plant is about 11 million kilograms, though USEC now rates the usable capacity as 8 million kilograms. Hence the available SWU capacity from commercial and military over the next ten years is about 170 million kg. (80 million commercial, plus about 90 million equivalent in downblended fuel) while the demand is only 120 million SWU in the same period. Thus, there is already a huge surplus of LEU fuel in the pipeline. It is already slowing down downblending in Russia, which is detrimental for security reasons.

Furthermore in 1993, the RAND Corporation estimated that in the year 2003 the U.S. surplus of HEU would be 339 tons. Other estimates range as high as 600 metric tons (total including the already declared surplus).3 A U.S. declaration of further surpluses is likely to result in Russian declarations as well, especially if there is a market for the fuel at reasonable prices. Further, the reduction of nuclear weapons under the Strategic Offensive Reduction Treaty (SORT) signed in the Spring of 2002 by the United States and Russia is likely to increase the HEU surplus over the medium-term. This is very desirable for security reasons, especially as further downblending will remove large amounts of weapons usable HEU from potential diversion.

Approval of a project to build a new enrichment will hinder declarations of more surplus HEU. There are likely to be commercial pressures against such declarations in the face of a continuing glut in LEU market when both commercial SWU capacity and equivalent SWU capacity from downblending are taken into account. Moreover, LES has not specified whether and how its planned project would affect the government's plan to develop advanced centrifuge technology in collaboration with the United States Enrichment Corporation.

The down blending of military U.S and Russian HEU into LEU not only provides LEU for the U.S. market but is crucial for reasons of international security, and disarmament commitments under Article VI of the Non-Proliferation Treaty (NPT) of nuclear weapons.4 The construction of the LES uranium enrichment plant by creating an

3 Arjun Makhijani and Annie Makhijani. *Fissile Materials in a Glass Darkly, Technical and Policy Aspects of the Disposition of Plutonium and Highly Enriched Uranium,* IEER Press, 1995, p.73

4 Article VI of the NPT states that: "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a Treaty on general and complete disarmament under strict and effective international control."

overproduction of LEU accompanied by a potential depreciation of the price of uranium fuel would interfere with the only effective program of disposition of surplus fissile material.

The fuel fabrication of nuclear fuel from the surplus of military HEU has also the advantage of circumventing most the front-end - uranium mining, milling, conversion, and enrichment - of the nuclear fuel cycle. These operations specially uranium mining and milling are hazardous to the workers and create huge amounts of wastes, radioactive and well as chemical, with their associated hazards to workers and the public.

Depleted uranium tails disposition

According to Section 3113 of the 1996 USEC Privatization act the DOE "shall accept for disposal low-level radioactive waste, including depleted uranium if it were ultimately determined to be low- level radioactive waste, generated by [...] any person licensed by the Nuclear Regulatory Commission to operate a uranium enrichment facility under sections 53, 63, and 193 of the Atomic Energy Act of 1954 (42 U.S.C. 2073, 2093, and 2243).

On this basis LES suggests that the NRC incorporate this provision in its Order as a "plausible strategy" for the disposition of the depleted uranium tails.

1. Current and proposed uses of depleted uranium

Depleted uranium is still classified as a source material and might remain so for some time. It has been used as fertile material to produce plutonium in the U.S. breeder reactor program. Although there is no ongoing breeder reactor program the desire for such a program is strong within some sections of the nuclear establishment. The amount of DU is already so vast that there is no prospect that such a use could come anywhere near to constituting a major use even if breeder reactor technology were to be revived in the coming decades. There is no room in this application for DU resulting from new enrichment services.

Until now the utilization of depleted uranium, based purely on its physical properties, has involved very small amounts compared to the supply already at hand.5 More recently proposals have been made that could, if implemented, use up the entire inventory of depleted uranium.6 It has been proposed that the shielding properties of uranium could be used to fabricate casks for the transport and interim storage of the nation's spent fuel and high level wastes.7 However like the storage of spent fuel and high level wastes, this use

5 Small amounts have been used as armor piercing bullets, tank armors, shielding form medical and industrial radioactive sources, and counterweight in planes.

6 The inventory of depleted uranium is estimated to be 740 000 metric tons of UF_6 to which 12,000 metric tons per year from the enrichment activities of USEC need to be added.

7 W. J. Quapp, Starmet CMI, W. H. Miller, University of Missouri-Columbia James Taylor, Starmet CMI Colin Hundley, Starmet CMI, Nancy Levoy, Starmet Corporation *DUCRETE: A Cost Effective Radiation*

of depleted uranium would be temporary. Once the spent fuel is removed from the casks, the problem of the disposal of depleted uranium will still remain. In effect, the use of DU for transportation and interim storage casks is simply another method of interim storage for years or decades but it does not solve the problem of DU disposal.

Further, by proposing that these casks could be integrated in the waste package going into Yucca mountain, the industry has implicitly acknowledged what IEER is arguing below, that is: the radiological properties of depleted uranium dictate that it ought to be disposed of in a deep geological repository. Two other proposed uses of depleted uranium are:

- a material to fill the voids of the spent fuel waste packages and,
- as structural components of spent fuel waste package

It is claimed that they "may (1) reduce the long-term potential criticality in the repository, (2) improve repository performance, (3) provide radiation shielding" but also that they will (4) *dispose of excess DU*."8 (Emphasis added) This approach also further validates IEER's analysis that the radiological properties of DU are such that it should be disposed of in a deep geologic repository.

Therefore LES will have to devise a plan for the disposition of the depleted uranium tails, including plans for long-term storage on site for a period of several decades as well as a plan for its ultimate disposal in a deep geological repository.

2. NRC default classification of depleted uranium

However, in cases where it might be disposed of as a waste the Nuclear Regulatory Commission has put it by default into the category of class A low-level radioactive waste according to 10 CFR 61.55 (6). 10 CFR 61.55 allows near surface disposal. However, the inappropriateness of this default classification is demonstrated by the NRC's own assessment that shallow-land burial of depleted uranium could result in unacceptably high doses to future generations.9

3. The scientific reasons for disposing DU in a deep repository

We reproduce below the scientific reasons why depleted uranium should be put in the same classification as transuranic wastes for the purpose of waste management and

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Shielding Material, Paper Summary Submitted to Spectrum 2000, Sept 24-28, 2000, Chattanooga, TN

8 Charles W. Forsberg, *CERMET WASTE PACKAGES USING DEPLETED URANIUM DIOXIDE AND STEEL*, Article Prepared for 2001 International High-Level Radioactive Waste Management Conference American Nuclear Society Las Vegas, Nevada, April 29–May 3, 2001.

9 Final Environmental Impact Statement for the Construction and Operation of the Claiborne Enrichment Center, Homer Louisiana, NUREG-1484, Vol. 1, August 1994.

10 These scientific reasons are part of the *Comments of the Institute for Energy and Environmental Research on the Department of Energy Notice of Intent addressing the Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, Federal Register, Thursday, January 25, 1996 by Annie Makhijani and Arjun Makhijani 22 March 1996

disposal.10 This would mean that depleted uranium would have to be placed in a deep geological repository.

The current definition of TRU waste according to 40 CFR 191.01 (i) is: ". . .waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than twenty years, per gram of waste . . . ."

What matters to health and environmental considerations is the specific activity of the radioactive wastes, the nature of the radiation being emitted during the radioactive decay (alpha or beta and whether the decay is accompanied by gamma radiation) and, the energy per radioactive decay. Depleted uranium is, in these essential respects, the same as the transuranic constituents of TRU waste. The specific ways in which uranium or the transuranic radionuclides in TRU waste might affect people will, of course, depend on the chemical form of the waste, the packaging, and the disposal method.

There is one nominal difference between TRU waste and depleted uranium. TRU waste consists of elements with atomic numbers greater than or equal to 93 -- that is of elements with atomic numbers greater than uranium, whose atomic number is 92. But this is a difference of nomenclature; it has no bearing upon health and environmental issues.

A. Properties of depleted uranium

1. *Specific Activity*

The radioactivity per unit weight (specific activity) of depleted uranium metal is dominated by its principal constituent, uranium-238. It also depends somewhat on the exact extent to which uranium-235, and hence also uranium-234, have been separated and passed into the enriched uranium stream. It may vary from about 360 nanocuries/gram to about 450 nanocuries/gram. Even assuming that only uranium-238 remains, the specific activity would be still about 340 nanocuries/gram which is 3.4 times higher than that defining transuranic waste.11

The specific activity of other chemical forms is somewhat lower than for uranium metal, because when radioactive uranium is chemically bound with non-radioactive isotopes of elements like oxygen and fluorine, its specific activity is correspondingly lower. Table 1 shows the specific activity of four forms of depleted uranium. For convenience we have assumed a single reference value of 360 nanocuries/gram for the specific activity of uranium metal which is the lowest practical value in the range cited above.

Table 1 also shows, for reference, the minimum specific activity of transuranic waste as defined by regulations and the radioactivity of ore containing 0.2 percent uranium.

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10 These scientific reasons are part of the *Comments of the Institute for Energy and Environmental Research on the Department of Energy Notice of Intent addressing the Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, Federal Register, Thursday, January 25, 1996 by Annie Makhijani and Arjun Makhijani 22 March 1996.

11 This discussion assumes that the DU results from enrichment of un-reprocessed uranium.

Table 1
Specific Activities of various chemical forms of depleted uranium, TRU waste and 0.2% uranium ore

Chemical form	Specific activity, nCi/g
uranium metal (U)	360
uranium oxide (U_3O_8)	300
uranium tetrafluoride (UF_4)	270
uranium hexafluoride (UF_6)	240
transuranic activity in TRU waste	>100 (See note 2)
0.2 % uranium ore	4 (See note 3)

Notes for Table 1
1. Specific activities of the four forms of uranium have been rounded to two significant figures, and that of uranium ore to one significant figure.
2. The minimum limit of 100 nanocuries/gram of transuranic elements for waste to be classified as TRU waste includes only those isotopes of transuranic elements with half-lives greater than 20 years. The most common isotope in TRU waste that is eliminated from the counting in this way is plutonium-241, which has a half-life of 14.4 years. However the decay product of plutonium-241, americium-241 is included in TRU waste because it has a half-life of about 432 years. All these uranium isotopes we are dealing with in these comments have half-lives far longer than 20 years.
3. The specific activity of 0.2 percent uranium ore shown includes all decay products of uranium-238 up to and including radium-226, assuming they are in secular equilibrium with uranium-238. Radon-222, and its decay products are not included.

It is clear from Table 1 that depleted uranium is comparable in specific activity to transuranic waste. This conclusion is independent of the chemical form of the depleted uranium. Note that depleted uranium is far more radioactive than uranium ore because the ore is mixed with large quantities of non-radioactive materials. Thus, putting depleted uranium in mines is in no way like replacing the original material that was mined out of the ground. Rather it is analogous to putting TRU waste in the ground.

2. *Mode of decay, energy of decay, and half-life*

The main radionuclide of concern in most TRU waste is plutonium-239. Other radionuclides that are present in significant quantities are plutonium-240, plutonium-238, neptunium-237, and americium-241. The predominant mode of decay of all of these radionuclides is alpha decay. That is also the case with all three uranium isotopes (uranium-238, uranium-234, and uranium-235) present in depleted uranium. In all these cases, the emitted alpha particles have energies between 4 and 6 MeV, so that the total energy deposited in tissue per picocurie of radioactive material in the body is the same. Thus, once a unit of radioactivity of TRU waste or of depleted uranium is in the body, the amount of radiation dose per unit of time is approximately the same.

Table 2 shows the principal characteristics of concern of the main radionuclides in TRU waste and in depleted uranium. Note that the decay products of uranium-238 build up over hundreds of thousands of years, and we have ignored these for the sake of argument in these comments.3

Table 2
Properties of Uranium Isotopes and Selected Transuranic Elements

Isotope	Main decay mode	Alpha particle energy, MeV	Half-life, years	Comments
uranium-238	Alpha	4.1	4.46 billion	
uranium-234	Alpha	4.8	245,000	
neptunium-237	Alpha	4.8	2.14 million	
plutonium-238	Alpha	5.5	87.7	
plutonium-239	Alpha	5.1	24,110	
plutonium-240	Alpha	5.1	6,537	
plutonium-241	Beta	see note 2	14.4	not included in TRU waste definition
americium-241	Alpha	5.5	432	strong gamma emitter

Notes
1. All energies rounded to two significant figures. The alpha emitting radionuclides emit alpha particles with more than one characteristic energy, with each energy level being produced with a known probability. The alpha particle energy shown is an approximate average of these particles energies, weighted by the emission probability.
2. Plutonium-241 is not included in the definition of TRU waste since it has a half-life of less than 20 years Its beta particle energy is 0 021 MeV.

Conclusion

When existing capacity and ongoing down blending program of HEU are taken into account, there is no need for an additional domestic uranium enrichment capacity in the near to medium term. Further, it would be highly desirable to defer consideration of any new capacity for national and global security reasons since construction of new enrichment capacity will hinder additional surplus declarations both in the United States and Russia, given that existing downblending has already created an effective overcapacity in enrichment services.

Therefore, the "no action alternative" will have to be addressed by both LES and the NRC staff taking into account the current and potential situation regarding the blending down of surplus military HEU.

The disposition of depleted uranium tails will need to be addressed based on the radiological hazards of this material that require that it be disposed of in a deep geological repository. The construction of such a repository will be a major economic and political hurdle facing DU disposal, and hence the proposed plant. LES must address it before any environmentally credible application for a new enrichment plant can be considered.

3 In general, the specific activity of wastes containing mainly plutonium-239 will decline as time progresses, but that of wastes containing mainly uranium-238 will increase as time progresses, due to the differences in half-lives of the decay products of these two radionuclides