HEU CORE CONVERSION OF RUSSIAN PRODUCTION REACTORS: A MAJOR THREAT TO THE INTERNATIONAL RERTR REGIME

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ABSTRACT

It is important not to lose sight of the ultimate objective of the RERTR program – to reduce and eventually eliminate international civilian commerce in nuclear weapons-usable, highly enriched uranium (HEU), and thereby significantly lower risks of this material being stolen or diverted by terrorists or states to make nuclear weapons. The good news is that despite a few bumps in the road a few years ago, the RERTR program is now back on track to phasing out remaining commerce in HEU for research reactors. The bad news is that a new threat to the RERTR regime has arisen from outside the research-reactor community. The United States and Russia are contemplating conversion of the cores of Russia's three remaining military plutonium-production reactors *to HEU fuel* -- exactly opposite to what the RERTR program has sought to achieve -- in order to halt the reactors' production of weapons-grade plutonium. While we embrace the objective of halting production of weapons-grade plutonium, the HEU conversion plan would reverse two-decades of progress by the RERTR program and increase civilian HEU commerce by five times, to levels unprecedented in history. Fortunately, an alternative LEU core conversion option is available for the Russian reactors, which could halt weapons-grade plutonium production without inadvertently increasing commerce in weapons-grade uranium. The research-reactor community has moral standing to demand that U.S. and Russian leaders reject the HEU core conversion option in favor of the LEU option.

INTRODUCTION

During the course of this conference's complicated technical discussions, it is important not to lose sight of the simple, but vitally important, objective of the Reduced Enrichment for Research and Test Reactors (RERTR) program. It is to reduce and eventually eliminate international civilian commerce in nuclear weapons-usable, highly enriched uranium (HEU), and thereby significantly lower risks of this material being stolen or diverted by terrorists or states to make nuclear weapons. The urgency of this objective was underscored dramatically by former UNSCOM inspector Scott Ritter's revelation last month that Iraq apparently possesses all the components of three workable nuclear weapons -- except the requisite HEU.

THE GOOD NEWS -- "INTERNAL" THREATS TO THE RERTR PROGRAM MOSTLY RESOLVED

From its founding in 1978 until a few years ago, the RERTR program made steady progress toward this goal -- developing alternate fuels of non-weapons-usable, low-enriched uranium (LEU), and providing technical assistance necessary to enable reactor operators to convert their cores to such fuel. In the early 1990s, however, a number of threats to the regime arose within the research reactor community. The good news in 1998 is that almost all of these "internal" threats to the RERTR regime have been resolved favorably:

- The RERTR program has renewed development of ultra-high density LEU fuels, with initially promising results, to enable conversion of the few remaining research reactors that still require HEU fuel.

- The United States has resumed "take-back" of U.S.-origin spent fuel from foreign operators that cooperate with the RERTR program, restoring an important incentive for conversion.

- The RERTR program also has made significant progress in developing LEU targets for production of medical radio-isotopes, currently the other main civilian use of HEU, and Canada recently agreed to cooperate actively with U.S. development of LEU targets for its new Maple reactors.

- France and China have announced that their next-generation, high-power research reactors will use LEU fuel.

- The United States canceled its planned Advanced Neutron Source, which was to have used HEU fuel, and which threatened to undermine the goals and principles of RERTR.

- The United States has conducted feasibility studies on converting its own government research reactors, to complement the ongoing conversion of U.S. university research reactors, and to make clear that no state is exempt from the RERTR program.

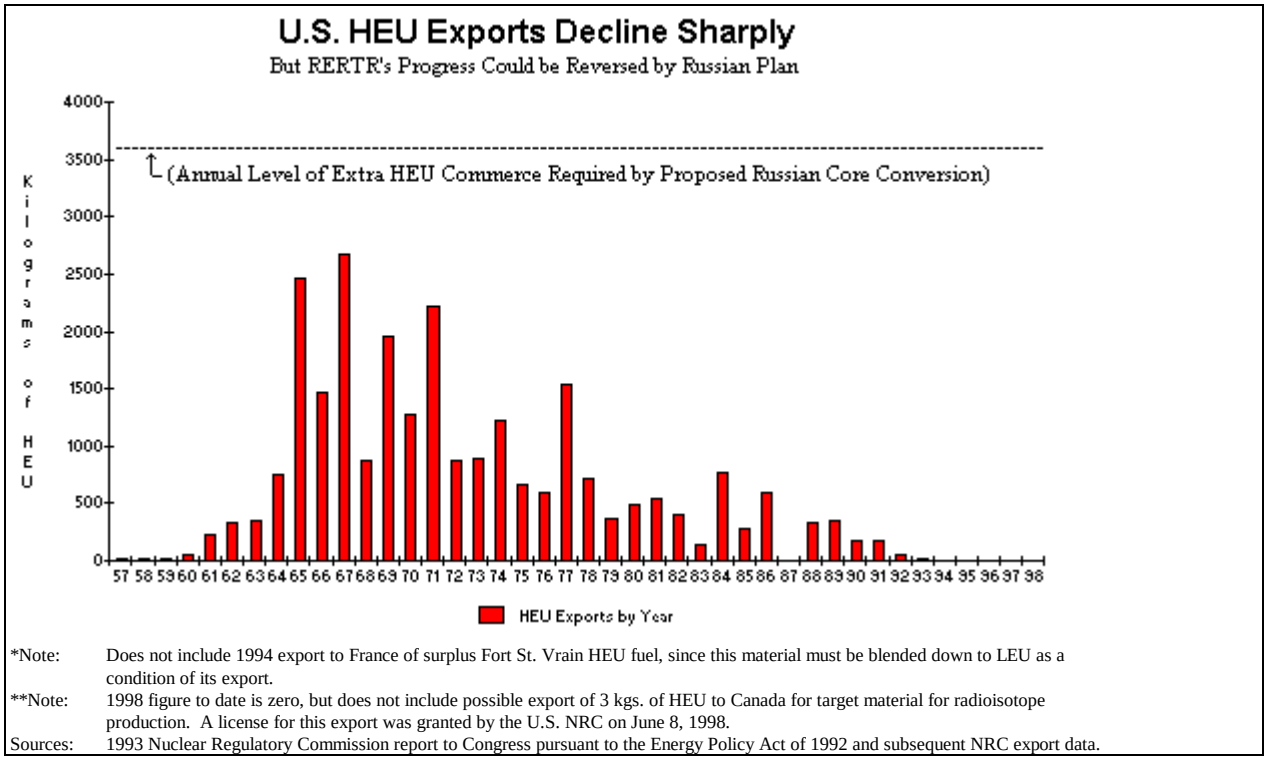
- There is new hope that Germany's FRM-II, which threatens to become the first new high power reactor in more than a decade to violate the RERTR regime by being built to use HEU, may now be constrained to use LEU due to the recent federal elections in Germany. Since 1987, 14 new research reactors (of power at least one megawatt) that are designed to use LEU fuel have started construction or been planned (five are completed, four are under construction, and five have yet to start construction). Except for the FRM-II, no other new research reactor is even contemplating HEU fuel.

- The RERTR program has become truly universal, as Russia and China have cooperated for several years to enable conversion of reactors in, and supplied by, those two states, paving the way for eventual elimination of all remaining civil HEU commerce worldwide.

- Despite earlier announcements, Russia has not yet exported any HEU to Western reactor operators, which could undermine the RERTR program and encourage Russia to seek other customers who might lack impeccable non-proliferation credentials. (Russia previously had ceased exporting uranium above 80%-enrichment to its former East bloc trading partners.) There is no need for such Russian exports because, as we noted in our presentation at last year's RERTR meeting in Jackson Hole, the United States -- under the Schumer Amendment to the Energy Policy Act of 1992 -- is legally able to export HEU to any reactor that cannot yet utilize LEU, so long as its operator has committed to convert as soon as suitable LEU fuel is developed.

- The new manager of the HFR Petten reactor -- one of the few reactors operating outside the principles of RERTR by not converting to available LEU fuel -- has indicated willingness to convert the reactor as soon as a feasibility study and re-licensing can be completed successfully. If this commitment is formalized, the reactor would become eligible for U.S. HEU exports to satisfy any legitimate interim need for HEU prior to the completion of conversion. Thus, Petten has no need to import Russian HEU, and we urge that ongoing negotiations between Euratom and Russia for this purpose be halted immediately.

As a result of these developments, the RERTR program continues to build upon its earlier progress, as can be seen by the trend in U.S. HEU exports, which account for virtually all international HEU commerce to Western-supplied research reactors (Figure 1). Such exports have declined from a high of nearly three metric tons in 1967, to 1.5 metric tons in 1977, the year prior to establishment of the RERTR program, to zero during the last five years.



*Note: Does not include 1994 export to France of surplus Fort St. Vrain HEU fuel, since this material must be blended down to LEU as a condition of its export.

**Note: 1998 figure to date is zero, but does not include possible export of 3 kgs. of HEU to Canada for target material for radioisotope production. A license for this export was granted by the U.S. NRC on June 8, 1998.

Sources: 1993 Nuclear Regulatory Commission report to Congress pursuant to the Energy Policy Act of 1992 and subsequent NRC export data.

Figure 1. U.S. HEU Exports Decline Sharply

Only a handful of research reactors worldwide continue to require fresh supplies of HEU. The status of Western-supplied reactors is summarized in Figure 2.

Status of Conversions
(not including Chinese- and Russian-supplied reactors)

	Number of Reactors	Converted, Converting or Shutting Down	Can't Convert to Existing Fuels	Able to Convert but Refusing
United States (university reactors* & others at least 1 MW)	23	18	5 (see note 1)	0 (see note 2)
Non-U.S. Reactors using U.S. HEU (at least 1 MW)	42	37	3 (see note 3)	2 (see note 4)

*U.S. university reactors are being converted even if they had low-power (less than 1 MW) and lifetime HEU cores that did not require fresh fuel. This is in recognition of the extreme vulnerability of university reactors to theft, due to traditionally lax security on most campuses. Other low-power reactors in the United States and elsewhere are not now planned for conversion under the RERTR program, because they do not require fresh shipments of HEU.

[1]DOE's ATR (INEL) and HFIR (ORNL), the Department of Commerce's NIST reactor, and the university reactors at MIT and University of Missouri - Columbia. A sixth reactor, the HFBR (BNL), is shut down due to a tritium leak and not expected to re-start; it is counted in the chart as "shutting down."

[2]DOE's BMRR (BNL) is currently shut down. A feasibility study indicates the reactor can be converted to LEU, and its operator recently stated willingness to convert the reactor if it ever is to be re-started. Thus, it is included in the 18 reactors that are converting or shut down. Two other facilities, the Omega West (LANL) and Tower Shielding (ORNL) reactors, have recently been shut down and are not included in the total of 23 U.S. research reactors.

[3]France's HFR and Orphee, and Belgium's BR-2.

[4]Germany's FRJ-2 and South Africa's Safari I. The FRJ-2 may shut in the next few years and reportedly does not require further shipments of HEU. The Petten reactor, operated by the EU's JRC, has been removed from this category because it has indicated its intention to convert.

Figure 2. Status of Conversions of Western-Supplied Reactors

Including reactors in, and supplied by, Russia and China, worldwide annual requirements for fresh HEU for research-reactor fuel and targets is estimated to be less than a ton. As the RERTR program finalizes development of LEU targets and ultra-high density LEU fuels -- and as some older reactors shut down -- remaining annual commerce in HEU is likely to decline even further. To summarize the good news, the RERTR program is making steady progress towards its goal of eliminating international civilian commerce in HEU, and thereby blocking a vulnerable pathway to nuclear proliferation and nuclear terrorism.

THE BAD NEWS -- A NEW "EXTERNAL" THREAT TO THE RERTR PROGRAM

Ironically, the latest and most severe threat to the RERTR program's two decades of success in reducing risks of nuclear terrorism and nuclear proliferation comes from outside the research-reactor community. The United States and Russia are contemplating conversion of the cores of Russia's three remaining military plutonium-production reactors *to HEU fuel* -- exactly opposite to what the RERTR program has sought to achieve -- in order to de-militarize these reactors and cease their production of weapons-grade plutonium. These three large reactors are estimated to require about 3.6 metric tons of fresh HEU fuel annually. Thus, in a single blow, the Russian core-conversion plan would reverse two-decades of progress in reducing international civil HEU commerce. It would increase civilian commerce in HEU by five times, taking it to levels unprecedented in history, and raising associated risks of nuclear proliferation and nuclear terrorism.

The Russian HEU core-conversion plan also raises special security risks due to the design of the fuel and uncertainties in Russian physical protection measures. Together, the three reactors annually would require nearly 200,000 fuel elements, each containing U-235 weighing less than 17 grams. Such small fuel elements would be especially vulnerable to theft or diversion, not only as fresh fuel but also as spent fuel, because after a cooling period each tiny spent element would not emit sufficient radiation to be "self-protecting."

Moreover, the fresh HEU would be shipped over long distances from Tomsk-7, where it is to be converted into oxide form, to one or both of two potential fuel fabricators, Electrostal and Novisibirsk, and then to the production reactors. Underscoring the risk, U.S. government fissile-material security experts have expressed concern that required rail shipments of such material in Russia would be less secure than truck shipments.[1] To make matters worse, Russia intends to reprocess the spent fuel, separating out the uranium that still would be enriched approximately to 83% -- quite suitable for nuclear weapons -- thereby raising yet another risk of theft or diversion.

The Russian HEU core-conversion plan would make a mockery of the RERTR program, and inadvertently undermine the commitment of some research-reactor operators to proceed with planned conversion to LEU fuel. In Russia, such operators certainly would question why they are being put through all the trouble of conversion to reduce national HEU commerce by a few hundred kilograms annually while the production-reactor conversion increases such commerce by several tons annually. Resistance to conversion could well spill over to Western operators, who justifiably would ask why Russia can be trusted with HEU but not they? Ultimately, this could raise the specter of a permanent two-tier system, in which those reactor operators who previously cooperated with the RERTR program by converting to LEU would be penalized for their good faith -- being put at a competitive disadvantage in relation to operators who now reject the RERTR program.

Ironically, the ostensible goal of the Russian core-conversion program is to enhance global security. Indeed, the three reactors continue to produce about 1.4metric tons annually of weapons-grade plutonium in spent fuel, which must be reprocessed because it corrodes in water.

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[1] Dr. Frank von Hippel, Princeton University, personal communication, October 16, 1998.

Stopping such plutonium production is essential to capping and ultimately reducing Russian stockpiles of nuclear weapon materials -- to foster arms-control and nuclear nonproliferation objectives. In 1997, the United States and Russia signed an agreement to halt plutonium production at the three reactors by the year 2000, by converting their cores. (The reactors cannot simply be shut down, because they also produce needed heat and electricity.) However, it makes little sense to reduce one proliferation risk by increasing another, especially if there is a better alternative.

Fortunately, there is a better alternative to converting the Russian cores to HEU fuel. A feasibility study, prepared by a Russian team with the assistance of the RERTR program and presented at this conference, indicates that it should be possible to convert the Russian cores to LEU fuel without substantial delay or increase in cost. [1]

If pursued aggressively, the switch to LEU should cause no more than a seven-month delay in conversion. That is because the required, two-year irradiation test of this fuel could begin as soon as March 1999, only seven months after the August 1998 start of the HEU test of identical duration. There is no reason why post-irradiation examination (PIE) and licensing of the LEU fuel should take any longer than for the HEU fuel. (Those advocating conversion to HEU exaggerate the delays of the alternative fuel, by claiming the LEU fuel would require a much longer time for PIE and licensing, because other tests previously have been conducted on the HEU fuel.)

In addition, there is good reason to believe the proposed LEU fuel (19.75%-enriched) will perform successfully, as it is only marginally different from another fuel (21%-enriched) that previously was used successfully in at least one of the production reactors. Accordingly, there is no reason why full-scale production of LEU fuel should not occur concurrent with the ongoing irradiation testing, as is now planned for the HEU fuel.

Assuming no unforeseen contingencies, any claim that the LEU alternative would delay conversion by more than seven months is based on bureaucratic political opposition, in Russia and the United States, rather than scientific or technical obstacles. Moreover, if fuel testing turns out *not* to be the rate-limiting step in conversion, due to expected delays in other required reactor and security modifications, it is possible that the switch to LEU would result in an even shorter delay in conversion, or none at all.[2]

The Russian team reports that any extra costs of the LEU option would be marginal. One such cost results from the fact that each LEU fuel element would require more U-235 than its HEU counterpart. However, it turns out the difference per element is marginal -- less than one gram. Likewise, capital costs for reprocessing are also expected to be slightly higher for LEU,

[2] Other required upgrades that could delay conversion include relining channels with zirconium, installing missing emergency core cooling systems, adding neutron absorbers, and modernizing control systems. In addition, it would be advisable to upgrade physical security at the fuel fabrication plants prior to further production of HEU fuel. However, such upgrades are not scheduled for completion until at least 2001, whereas HEU fuel fabrication is scheduled to commence in 1999. Frank Von Hippel, Princeton University, personal communication, October 16, 1998.

but the Russian team reports this amount is an insignificant portion of the total cost of reprocessing. This difference in cost would disappear altogether if the Russians avoided reprocessing either spent fuel. Other marginal extra costs could result from a possibly greater volume of scrap recycle and more demanding extrusion requirements during LEU fuel fabrication. Off-setting these small extra costs of the LEU option, however, would be potential savings from avoiding the maximal physical security upgrades for facilities and transportation required under the HEU option. Overall, there is no evidence that an LEU core-conversion would be significantly more expensive than the planned HEU option.

SUMMARIZING THE OPTIONS FOR THE RUSSIAN REACTORS

There are three alternative outcomes for the Russian production reactors.[3] The following comparison assumes the reactors operate for another ten years beyond 2001, the estimated completion date of the proposed HEU conversion. The calculation of resulting commerce in weapons-grade nuclear materials is based on the ten years following this projected conversion date.

1. No Core Conversion -- Russia would continue to produce and separate out 1.4 tons of weapons-grade plutonium annually. This would undercut ongoing efforts to reduce Russia's stockpile of nuclear weapons-usable material, set back arms control efforts, and perpetuate risks of theft and diversion from Russia's reprocessing activities. **Bottom Line: Commerce in about 14 tons of weapons-grade plutonium, at risk of theft or diversion.**

2. Core Conversion to HEU -- Russia would convert the cores of all three production reactors to HEU as soon as possible. (Under the 1997 agreement, all three conversions were to be completed by the year 2000. It now appears that completing even one by that date is unlikely.) Russia would halt the production of 1.4 metric tons annually of weapons-grade plutonium, reducing associated risks of theft and diversion. However, to do so, it would have to increase commerce in bomb-grade uranium by 3.6 metric tons annually, including long-distance shipments of fresh fuel elements in a form particularly vulnerable to theft and diversion. Spent fuel would be reprocessed, separating out HEU and thereby raising further risks. In addition, the international RERTR effort to reduce and eventually eliminate remaining HEU commerce would be undercut severely. **Bottom Line: Commerce in 36 metric tons of bomb-grade uranium, at risk of theft or diversion.[4]**

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[3] Some have proposed a fourth option, initial conversion to HEU followed by subsequent conversion to LEU, but this is impractical in two regards. First, it likely would devolve into perpetual reliance on HEU fuel, as Russia would be reluctant to convert its reactors twice. Second, it would be the most costly option, because Russia would have to pay first for the costs of physical security upgrades for HEU fuel, and later for the marginal extra costs of using LEU fuel.

[4] The HEU and LEU conversion options also would produce relatively small amounts of plutonium in their spent fuel. Over ten years, the HEU option would produce on the order of 0.03 metric tons of plutonium, and the LEU option just under one metric ton. However, it is not certain that this plutonium would be separated from the spent fuel by reprocessing under either or both of these options, so it is excluded from the bottom line.

3. Core Conversion to LEU -- Russia would convert the cores of all three production reactors to LEU as soon as possible, delaying conversion by up to seven months beyond the HEU plan. Due to the possible delay in conversion, the reactors would produce plutonium for up to seven months longer than under the HEU plan, increasing Russia's stockpile of plutonium by no more than one metric ton. After the conversion, there would be no further production of weapons-grade plutonium and no increase in HEU commerce. **Bottom Line: Commerce (prior to conversion) in up to one metric ton of weapons-grade plutonium, at risk of theft or diversion.**

Figure 3 compares the three options for Russia's production reactors, and assumes the maximum projected delay of seven months for the LEU option. Calculations of resulting commerce in weapons-grade material are based on ten years of operation after the projected date of conversion under the HEU option.[5]

Strategy	Resulting Nuclear Weapons-Grade Commerce[6]	Bomb Potential[7]
No Core Conversion	14 metric tons weapons-grade Pu	1,750 SQ's
HEU Core Conversion	36 metric tons HEU	1,440 SQ's
LEU Core Conversion	1 metric ton weapons-grade Pu	125 SQ's

Figure 3. Summary of Options for Russian Production Reactors

We can see that the LEU option, despite its marginal delay compared to HEU, is far preferable from the standpoint of reducing overall commerce in nuclear weapons-usable materials, and associated risks of nuclear proliferation and nuclear terrorism. What is perhaps more surprising is that the HEU core-conversion option may be worse than doing nothing. It actually would increase commerce in nuclear weapons-usable materials -- in terms of total tonnage -- beyond that in the no-action option of allowing the reactors to continue producing plutonium. Moreover, the bomb-grade material under the HEU option might be more vulnerable to theft and diversion, due the nature of the fuel and transportation requirements.

A CALL TO ACTION

The international research-reactor community, which has spearheaded efforts to reduce risks of nuclear terrorism and nuclear proliferation by reducing civilian commerce in bomb-grade

[5] The only such commerce under the LEU option would result from the delay in conversion. If this delay were reduced for reasons discussed above, the marginal commerce in weapons-grade material under the LEU option could be reduced even further to zero.

[6] The HEU and LEU conversion options also would produce relatively small amounts of plutonium in their spent fuel. Over ten years, the HEU option would produce on the order of 0.03 metric tons of plutonium, and the LEU option less than one metric ton. This material would be of commercial grade, as opposed to the weapons-grade material that is currently produced. Moreover, it is not certain that this plutonium would be separated from the spent fuel by reprocessing under either or both of these options, so it is excluded from the bottom line.

[7] An SQ is a "significant quantity" of fissile material -- 8 kgs. of Pu, or 25 kgs. of HEU -- traditionally considered sufficient for an implosion-type nuclear weapon, for purposes of International Atomic Energy Agency safeguards.

uranium, has unique standing to speak out on the proposed Russian HEU core-conversion plan. Many of you remember the similar bias in favor of HEU that used to exist within this community, and the skepticism and opposition that originally confronted the RERTR program, when it first proposed that operators could convert to LEU fuel without significant penalties in regard to cost or performance. But now, many of you have seen first-hand the benefits of LEU, which can produce equivalent reactor performance while avoiding the costs and risks associated with handling bomb-grade nuclear material.

The research-reactor community thus has moral standing to speak out on the core conversion plan. Many of you willingly expended the necessary resources and effort, and some of you even accepted small reductions in performance, in order to reduce commerce in HEU. You have every reason to be outraged that the U.S. and Russian governments would violate your good faith by proposing to increase civilian commerce in HEU to unprecedented levels, wiping out two decades of progress by the RERTR program that was obtained through your own sacrifices.

We hope you will make your voices heard to high government officials in the United States and Russia. The proposed HEU core-conversion is estimated to cost about $150 million, of which $80 million of hard currency is to be provided by the United States. Within weeks, the United States is scheduled to disburse a significant portion of those funds to Russia, after which it will be increasingly difficult to shift the conversion plan from HEU to LEU.

Vice-President Gore should make sure that no further funds are provided to Russia for core conversion until Russia embraces the LEU alternative, and that funds are provided immediately to enable commencement of LEU irradiation testing on schedule, in March 1999. Prime Minister Primakov should be urged to override Russia's bureaucratic tilt toward HEU and to facilitate expeditious conversion to LEU, the only option capable of halting production of weapons-grade plutonium without increasing commerce in bomb-grade uranium. The United States also should facilitate this outcome by agreeing to absorb extra costs, if any, stemming from the switch to LEU.

Over the course of two decades, the RERTR program -- and all of you who have participated in it -- have made the world a safer place to live. The Russian HEU core conversion program represents a direct threat to those gains and to all of your efforts. It is time for urgent action to preserve and sustain the vital objectives of the RERTR program.

REFERENCES

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