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The Nuclear Non-Proliferation Treaty's Obligation to Transfer Peaceful Nuclear Energy Technology: One Proposal of a Technology

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Abstract

This Essay discusses the technology transfer provisions of the Treaty on the Non-Proliferation of Nuclear Weapons ("NPT") and describes the Radkowsky Thorium Reactor, which is being developed as a peaceful nuclear energy technology.

THE NUCLEAR NON-PROLIFERATION TREATY'S OBLIGATION TO TRANSFER PEACEFUL NUCLEAR ENERGY TECHNOLOGY: ONE PROPOSAL OF A TECHNOLOGY

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INTRODUCTION

The Treaty on the Non-Proliferation of Nuclear Weapons ("NPT")[1] is the main document in the international effort to stop the proliferation of nuclear weapons. As stated in the preamble of the NPT, "proliferation of nuclear weapons would seriously enhance the danger of nuclear war," and devastation "would be visited upon all mankind by a nuclear war."[2] The NPT calls for a halt to proliferation of nuclear weapons and technology and also calls for the transfer of "peaceful" nuclear energy technology. This Essay discusses the technology transfer provisions of the NPT and describes the Radkowsky Thorium Reactor, which is being developed as a peaceful nuclear energy technology.

I. *BACKGROUND TO THE RADKOWSKY THORIUM REACTOR*

A. *The Treaty on the Non-Proliferation of Nuclear Weapons Obligation to Transfer Peaceful Nuclear Energy Technology*

Article IV(1) of the NPT asserts that parties to the NPT have an "inalienable right" to develop, research, produce, and use nuclear energy for peaceful purposes. Nuclear technology can be applied in many areas. For example, nuclear medicine is used in cancer treatment and radiation is used to eradicate pests from crops. The NPT, however, does not mention "nuclear technol-

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1. Treaty on the Non-Proliferation of Nuclear Weapons, Mar. 5, 1970, 21 U.S.T. 483, T.I.A.S. No. 6839; 729 U.N.T.S. 161 [hereinafter NPT].

2. *Id.* pmbl., 21 U.S.T. at 484, T.I.A.S. No. 6839 at 1, 729 U.N.T.S. at 169.

ogy." Instead, the NPT discusses "nuclear energy" and "atomic energy." There is no doubt that the NPT discusses an inalienable right to use nuclear reactors for peaceful energy production. Article IV(2) states, in part, that parties to the NPT "undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy."[3]

Perhaps the most interesting sentence of the NPT is in Article IV(2):

> Parties to the [NPT] in a position to do so shall also cooperate in contributing alone or together with other States or international organizations to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapon States Party to the [NPT], with due consideration for the needs of the developing areas of the world.[4]

In an ironic provision for the most important treaty regarding nuclear non-proliferation, Article IV(2) obligates the transfer of nuclear energy technology. The obligation is created for those NPT parties "in a position to" develop the application of nuclear energy for peaceful purposes. The United States clearly is such a country. Nuclear reactors were invented in the United States, and the United States has more operating nuclear power plants than any other country.

As an NPT party, the obligations created by Article IV(2) are binding on the U.S. Government. The NPT does not affect private U.S. companies desiring to transfer peaceful nuclear energy technology to other countries. Private U.S. companies must comply with laws and regulations pertaining to such transfers.

B. *United States Export Controls*

Section 57(b) of the Atomic Energy Act[5] allows the transfer of nuclear technology only upon receipt of an authorization from the Secretary of Energy. Part 810 of the Department of Energy regulations[6] detail the process of applying for such an authorization. Failure to comply with Part 810 carries stiff penal-

3. *Id.*, art. IV, cl. 2, 21 U.S.T. at 489, T.I.A.S. No. 6839 at 6, 729 U.N.T.S. at 173.
4. *Id.*
5. Atomic Energy Act, 68 STAT. 919 (1954).
6. 10 C.F.R. § 810 (1995).

ties, including jail sentences up to life imprisonment and fines up to US$20,000. By preventing private entities from transferring nuclear materials and technology without governmental approval, Part 810 serves as an important export control for national security purposes.

C. *Dr. Alvin Radkowsky*

NPT Article IV(2)[7] contains a treaty obligation that is binding on the United States. In order to comply with the requirement to transfer peaceful nuclear energy technology to other countries, the United States must identify peaceful nuclear energy technologies. One such technology that the Government is examining is the Radkowsky Thorium Reactor core ("RTR"). The RTR was invented by Dr. Alvin Radkowsky. From 1950 until 1972, Dr. Radkowsky simultaneously held the following two positions: Chief Scientist of the U.S. Naval Nuclear Propulsion Program and Chief Scientist of the U.S. Atomic Energy Commission, Office of Naval Reactors. In these positions, Dr. Radkowsky was the head of the design team for all nuclear reactors that propelled U.S. Navy ships. Dr. Radkowsky also was head of the design team for the World's first civilian nuclear power plant, which was located at Shippingport, Pennsylvania. Today, Dr. Radkowsky is concentrating on developing the RTR for peaceful nuclear energy production.

D. *The Link Between Nuclear Power Generation and Nuclear Weapons*

Approximately eighty-five percent of the World's almost 500 commercial nuclear power plants are a type known as a light water reactor ("LWR"). The fuel rods for LWRs are made with enriched uranium. At the end of their use in reactors, the fuel rods are removed. The spent fuel rods can be disposed of underground. For economic reasons, rather than dispose of the spent fuel rods, some countries reprocess the rods. Reprocessing extracts uranium that can be used in production of new fuel rods. Reprocessing also automatically extracts plutonium produced in the rods while they were in the reactor. It is generally

7. NPT, *supra* note 1, art. II, 21 U.S.T. at 487, T.I.A.S. No. 6839 at 3, 729 U.N.T.S. at 171.

acknowledged that plutonium extracted during reprocessing can be used in production of nuclear weapons.

The NPT helps ensure that spent fuel rods are not used to produce weapons. Article I forbids nuclear weapons states from transferring weapons technology to non-weapons states.[8] Article II forbids non-weapons states from accepting weapons technology.[9] Article III obligates each non-weapons state to accept safeguards in accordance with the International Atomic Energy Agency's ("IAEA") safeguards regime.[10] The IAEA has teams of inspectors who help assure that reprocessing is not occurring, or, if reprocessing is occurring, that enriched uranium and plutonium are not diverted to weapons use.

Most states that are parties to the NPT do not have nuclear weapons and are not seeking to obtain nuclear weapons. Such NPT parties are obligated to permit IAEA inspectors to enter their territory and determine whether they are complying with the NPT and the IAEA safeguards regime. Why have such states become parties to the NPT? What does the NPT offer such states? Article IV(2) provides an answer: such states can receive nuclear power plant technology.

II. *DR. ALVIN RADKOWSKY AND THE THREE MAIN PHASES OF NON-WEAPONS USE OF NUCLEAR REACTORS*

Nuclear weapons were invented by the U.S. Government in the 1940s during a program called the "Manhattan Project." After World War II, the United States and the Soviet Union entered into an arms race, developing increasingly more powerful nuclear weapons. Nuclear reactors were used to generate plutonium and other weapons-usable materials. Since the inception of the arms race, Dr. Radkowsky has been a leading figure in non-weapons uses of nuclear reactors. First, Dr. Radkowsky was chief scientist of the program that developed nuclear propulsion systems for ships. Second, Dr. Radkowsky was head of the design team for the World's first civilian nuclear power plant. Now, Dr. Radkowsky is chief scientist of the program developing the RTR, which can be retrofit into most of the World's existing nuclear power plants to upgrade them to take on many advantages, in-

8. *Id.*, art. I, 21 U.S.T. at 487, T.I.A.S. No. 6839 at 3, 729 U.N.T.S. at 171.
9. *Id.*, art. II, 21 U.S.T. at 487, T.I.A.S. No. 6839 at 3, 729 U.N.T.S. at 171.
10. *Id.*, art. III, 21 U.S.T. at 487, T.I.A.S. No. 6839 at 4, 729 U.N.T.S. at 172.

cluding making them essentially unable to produce weapons-suitable materials.

The following is a summary of the three main phases of non-weapons uses of nuclear reactors:

A. *Phase One: Propulsion of Navy Ships*

In 1950, the United States Navy undertook the first program designed to use nuclear reactors for non-weapons purposes. The Naval Nuclear Propulsion Program ("Program") was created to develop nuclear reactors to power ships. Admiral Hyman Rickover headed the Program.[11] Dr. Alvin Radkowsky was Chief Scientist of the Program from its inception until 1972. The Program developed the nuclear propulsion systems for the Nautilus and Seawolf submarines, as well as all other nuclear-propelled Navy submarines, aircraft carriers, and other ships. The Program was somewhat military-related because the ships were Navy vessels. However, the Program's technology is not directly related to weapons, and nuclear propulsion systems are used in other ships as well, including ice breakers.

B. *Phase Two: Civilian Nuclear Power Plants*

In an address to the U.N. General Assembly in 1953, President Eisenhower called for the use of "atoms for peace."[12] He argued that the dangers of the spread of nuclear weapons was one of the greatest security threats facing the world and that nuclear energy could peacefully be used globally in the generation of electricity. President Eisenhower's speech can be seen as establishing the framework for the NPT. The U.N. General Assembly followed the speech with a call for an international agreement on the prevention of wider dissemination of nuclear weapons. The NPT was signed at Washington, London, and Moscow on July 1, 1968 and entered into force on March 5, 1970. The NPT was extended indefinitely at an April 1995 review meeting of the parties held in New York.[13]

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11. Editorial, *The Legacy of Admiral Rickover*, CHI. TRIB., July 10, 1986, at C18. Admiral Hyman Rickover coordinated the construction of the World's first nuclear powered submarine and the first civilian nuclear power plant. *Id.*

12. Address Before the General Assembly of the United Nations on Peaceful Use of Atomic Energy, PUB. PAPERS 813 (1953).

13. 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, 34 I.L.M. 959 (1995).

In the 1950's, the Program built the World's first civilian nuclear power plant at Shippingport, Pennsylvania. Dr. Radkowsky headed the design team. The plant used a "seed and blanket" type of core, similar to the RTR core, described below. In 1977, the Shippingport plant was modified to use thorium in its core, in addition to enriched uranium, partly due to concern that uranium ultimately would be depleted in the Earth's crust. The plant was known as the Light Water Breeder Reactor ("LWBR") and was developed partly out of Dr. Radkowsky's belief that thorium and enriched uranium, used together as a nuclear fuel, can be superior to enriched uranium alone. Dr. Radkowsky is now completing his vision, with the RTR.

Shippingport was followed by the development of commercial nuclear power plants in the United States and, then, in other countries. The commercial nuclear power plants use enriched uranium in their fuel and do not use thorium. At the beginning of the industry, most experience was with enriched uranium nuclear fuels — not thorium — and the governmental regulatory systems were established based on receiving licenses for power plants that used the most well-known and proven technology. Additionally, although Shippingport had been a scientific success, it was not as cost-effective as power plants using enriched uranium fuels. Like enriched uranium fuels, Shippingport also produced weapons-usable materials in its spent fuel rods, so the inclusion of thorium was of little benefit.

C. *Phase Three: The Radkowsky Thorium Reactor*

The end of the Cold War marked the beginning of large reductions in nuclear weapons stockpiles in the United States and the former Soviet Union. During the Cold War, both countries built nuclear reactors to produce materials for use in nuclear weapons. Although the Cold War is over, the costs of ending it continue. These costs include the shut-down of unsafe plutonium-producing nuclear reactors in Russia and their replacement with new power plants. Another major cost is the disposition of the stockpiles of plutonium and highly enriched uranium. The stockpiles are growing rapidly as plutonium and highly enriched uranium are removed from warheads prior to destruction of the warheads in accordance with arms control treaties. Both countries are cooperating in financing these endeavors through such efforts as the Nunn-Lugar program, the International Science and Technology Center, and the United States Industry Coalition ("USIC"). USIC is a U.S. Government-supported company in New Mexico that assists in commercializing high-technology in the Newly Independent States of the Former Soviet Union ("NIS") and the U.S. Department of Energy ("DOE") national laboratories. USIC supports non-proliferation commercial products and the employment of NIS scientists and engineers who formerly engaged in weapons production. USIC has provided a grant to support the development of the RTR. The grant consists of funds from the U.S. Departments of Energy and State.

As the United States, the former Soviet Union, and other countries continue to produce electricity in their existing nuclear power plants, it is important that such plants be designed to minimize production of new quantities of weapons-usable materials. The less weapons-usable material in existence, the less chance it will end up in a bomb. But any system designed to meet this goal will only be used by industry if, economically, it meets or exceeds the performance of existing enriched uranium fuels. Hence, protecting the world from nuclear terrorism includes developing a cost-effective alternative to current technology. The RTR is a new type of nuclear fuel, designed to retrofit into existing LWR nuclear power plants, which comprise approximately eighty-five percent of the World's nuclear power plants. The RTR will render the nuclear power plants unable to produce materials that are suitable for nuclear weapons. The RTR will produce much smaller quantities of plutonium, and this plutonium will be of a type that is poorly suited for use in nuclear weapons. The mass and volume of high level radioactive waste in the spent fuel also will be reduced significantly. The RTR is being developed by Radkowsky Thorium Power Corporation in cooperation with Raytheon Nuclear Inc., Brookhaven National Laboratory, a Department of Energy national laboratory located on Long Island, New York, and the Russian Research Center "Kurchatov Institute" in Moscow, Russia.

III. *TECHNICAL ASPECTS OF NUCLEAR POWER GENERATION AND THE RADKOWSKY THORIUM REACTOR*

A. *Radkowsky Thorium Reactor Background*

The majority of the World's almost five-hundred nuclear power plants producing electrical energy are conventional LWRs using a uranium fuel cycle. The original intent concerning this technology was to have spent fuel reprocessed and to recover and recycle uranium and plutonium. Reprocessing produces large stockpiles of weapons-usable plutonium. This process has been slowed, principally by current fuel cycle economics and by concerns about the production and proliferation of nuclear weapons-usable materials. The result is that there is a substantial stock of plutonium, either separated or in spent fuel, and that plutonium will continue to be produced in substantial quantities for the foreseeable future. It is generally acknowledged that plutonium in spent fuel rods could potentially be used to make nuclear weapons, and that creates security and safety issues.

The RTR is a replacement thorium-based core for existing LWR plants that:

(1) Is proliferation-resistant, creating no weapons-suitable plutonium or uranium as a by-product;

(2) Uses thorium cost-effectively, with a design that significantly improves the economic performance of light water nuclear power plants. The natural uranium requirements are reduced by about 10% and fuel fabrication costs are reduced, with corresponding fuel cycle cost savings;

(3) Is based on proven reactor technology, similar to that already demonstrated in the Shippingport LWBR program and now being prepared for testing in Russia;

(4) Replaces the cores of existing nuclear plants; and

(5) Has significantly reduced waste disposal storage requirements, providing short-term and long-term economic benefits.

B. *Thorium as a Nuclear Fuel*

Nuclear power is generated in a nuclear reaction called fission, which takes place in the core of a nuclear reactor. Atoms split during fission, releasing energy. The nuclear core is comprised of fuel rods. Fuel rods can be produced from uranium

("U") or thorium ("Th"), which are naturally occurring elements. Natural uranium contains a fissile component, the natural element U-235, while natural thorium does not contain a fissile component. Nuclear power can be generated only with the presence of a fissile component. So, it is necessary to include uranium in a thorium-based core. When used in a nuclear core, thorium produces the man-made element U-233.

At an early stage of nuclear technology development it was determined that U-233 is superior to U-235 as a fissile material. This feature, and the fact that thorium is much more abundant as a natural ore than uranium, prompted numerous attempts to design and implement a nuclear reactor based on thorium fuel. The most notable example is the Shippingport LWBR.

The main challenge encountered in the design of a thorium-based system is the necessity to supplement natural thorium with a pre-generated fissile component. Several design solutions have been proposed and investigated, often attempting to balance non-proliferation and efficient fuel utilization objectives. Non-proliferation is achieved by substantially reducing the quantities of weapons-usable materials produced in the core or by producing those materials mixed with other materials from which they cannot be separated.

C. *The Thorium Challenge*

Several concepts for utilization of thorium in LWRs have been proposed and investigated in recent years. None was proven attractive enough to render significant investment into development and commercialization of new technologies. The main problem encountered in these attempts was the necessity to recycle the U-233 generated in the core in order to take advantage of the superior characteristics of U-233. This approach was discarded in recent years due to a significant proliferation potential of reprocessing and recycling pure U-233. U-233 is produced in thorium cores and can be extracted by reprocessing to make nuclear weapons.

An efficient utilization of thorium in a once-through cycle (no reprocessing) encounters a similar problem. The thorium core becomes more economically efficient as U-233 is built-up in the core. The U-233 build-up is quite slow. During the long build-up, the thorium part of the core requires continuous "investment" of neutrons created by fissioning U-235 (i.e., a large initial investment in uranium, which must be included in the core). In order to "recover" this investment in terms of fuel utilization gains by taking advantage of superior U-233 properties, the thorium-based fuel should be burned longer than a uranium core. This goal is achieved in the RTR.

D. *The Radkowsky Thorium Reactor Solution*

The RTR, invented by Dr. Alvin Radkowsky, offers a solution to the thorium utilization problem. In the RTR, the weapons-usable U-233 is mixed with a sufficient quantity of U-238 (a non-weapons-usable uranium isotope) to assure that the produced U-233 is diluted to a non-weapons usable concentration.

The main idea is to separate spatially the thorium part of the fuel rods and U-235 fissile component of the core. This separation allows separate fuel management schemes for the thorium part of the core ("blanket") and fissile part of the core ("seed"). The design objective of the blanket is efficient generation in the core of U-233, while the design objective of the seed is to supply neutrons to the blanket in the most economic way (i.e., with minimal investment of natural uranium).

The main design solution is based on a seed-blanket unit ("SBU") design of the core. The SBU provides the necessary flexibility to satisfy a major design constraint — full compatibility with existing LWR power plants. In addition, the separation of the seed and blanket in the SBU allows the necessary, and separate, optimization of seed and blanket components. The blanket (thorium) design is based on data from the LWBR program at Shippingport.

The RTR presents an alternative option to existing nuclear cores. It should be stressed that only the fuel assembly and fuel composition are modified, in addition to minor modifications of the core internals, while all other components of the nuclear power plant are retained. Thus, the safety characteristics of the power plants of current technology are preserved. There are two designs of the RTR: a "VVER" design for Russian LWRs and Pressurized Water Reactors ("PWR") design for western LWRs. Both are designed as fuel reloads for existing nuclear power plants.

E. *Spent Fuel Storage and Disposal Issues*

Used nuclear fuel rods that have been removed from reactors are called "spent fuel." Spent fuel storage and disposal issues are of major importance in nuclear power generation and are effectively addressed by the RTR. Spent fuel storage and disposal requirements are derived from four main parameters characterizing the spent fuel stockpile: mass and volume, radioactivity level, thermal power level, and toxicity.

PWRs are the standard type of LWR nuclear power plant used in the western world. A comparison of RTR and PWR current technology was performed on the basis of annual fuel discharge. The time dependence of the fuel stockpile parameters is important to the design of a technical solution for spent fuel storage and disposal. Three different time periods were considered in the analysis.

During the first period the spent fuel is stored in water pools at a reactor site. Spent fuel storage racks are placed under water in the fuel storage building adjacent to the reactor building. These racks hold the assemblies and maintain the required spacing between assemblies to provide radioactivity controls and residual heat removal. The space available at a reactor site is limited and additional fuel storage is eventually required — away from reactor ("AFR") storage.

The facilities for the second time period may be based on wet as well as dry storage technologies. There is a significant savings potential in expanding the existing wet storage at reactor sites and consequent delay in large capital investment in the away from reactor storage facilities.

The last time period includes long-term ("permanent") disposal of the fuel assemblies. For this period the levels of radioactivity and thermal power will define requirements of the storage space and technical solutions for the fuel containment. Based on the assumptions presented above, the analysis produced the following conclusions:

> (1) The RTR significantly reduces the annual heavy metal ("high level") fuel discharge. The total weight of the spent fuel is only thirty percent and the corresponding volume is about sixty percent of typical LWR spent fuel;
>
> (2) The reduced weight and volume result in a substantial reduction of the on-site spent fuel storage requirement. This

reduction may delay the need to transship the spent fuel to an AFR storage facility as well as its associated capital and transportation expenses;

(3) The total radioactivity level of the RTR spent fuel stockpile is reduced significantly compared with the corresponding LWR;

(4) The total thermal power level is reduced significantly;

(5) The comparison of the most "toxic" components of the spent fuel of the RTR and LWR indicate that RTR repository will be significantly less toxic;

(6) The RTR cycle design does not require modifications of the external assembly dimensions or major changes in the core's internal structure and composition. Therefore, it is reasonable to assume that storage and disposal of the irradiated structural materials will be identical to the standard LWR;

(7) The spent fuel storage facilities always include neutron absorbing devices to prevent recriticality ("radioactivity"). It should be noted that RTR spent fuel consists of two parts with different compositions. The first part is spent seeds; its criticality at end of life is similar to that of a standard LWR fuel. The second part is spent blankets; its criticality is much lower than that of the LWR fuel. Thus, it is expected that the overall requirements of the RTR repository measures to prevent re-criticality will be lower than those of the LWR repository; and

(8) Requirements for the permanent disposal of spent fuel depend on the mass of the fuel as well as on the radioactivity and heat emission levels. The RTR fuel cycle reduces the problem of permanent spent fuel disposal, providing significant economic savings.

F. *Proliferation Resistance of the Radkowsky Thorium Reactor*

One of the main concerns related to the nuclear power industry is the potential for diverting the fissile component of the spent fuel for production of weapons. Preventing diversion of fissile materials is a main goal of the NPT and the IAEA safeguards regime. To assemble a nuclear explosive device, one needs a certain amount of fissile material. The materials of interest are enriched U-235, plutonium, and U-233. The quality of the material is important for the construction of an explosive device. Extensive studies by the Nonproliferation Alternative

Systems Assessment Program concluded in 1980 that all of the existing and proposed fuel systems are subject to proliferation potential.

The lowest fissile U-235 content for the construction of a nuclear weapon is the (somewhat arbitrary) value of 20%. This means that at least 20% of the uranium in a uranium bomb must be U-235. This value is adopted by international organizations as a threshold. Similarly, the quality of plutonium affects the ease of construction and the efficiency of a plutonium bomb. Studies of the plutonium composition of the RTR spent fuel stockpile and its comparison with the weapon grade and PWR reactor grade material indicated significantly increased proliferation resistance of the RTR fuel cycle as follows: (1) the total amount of plutonium produced annually is reduced by over eighty percent; (2) the isotopic composition of the seed plutonium, and especially blanket plutonium, requires a significant increase of the critical mass, making it far more difficult to produce a weapon; (3) increased content of plutonium-240 and plutonium-242 increases the spontaneous fission rate of the RTR plutonium mixture and causes significant yield degradation of the weapon device based on plutonium diverted from the RTR; and (4) higher content of plutonium-238 increases thermal power production of the plutonium mixture, which presents a serious obstacle to building a stable and reliable explosive device.

Each of the above points alone would make the RTR's spent fuel proliferation resistant. Taken together, the above points make it completely implausible to create a weapon from the RTR's spent fuel. The RTR is based on extensive utilization of thorium which produces, through a nuclear reaction, fissile U-233. U-233 has been determined to be at least as efficient as U-235 as a weapon material. Therefore, a special effort was invested in the RTR design to create effective barriers to diversion of U-233. The U-233 created in the blanket is denatured (mixed) with U-238, which was added to thorium. The amount of U-238 added for dilution of fissile components was carefully chosen to reduce the overall content of fissile uranium isotopes below 20%. In principle, all uranium isotopes may be chemically separated from the blanket spent fuel and be further enriched by standard industrial methods. There are, however, major barriers to this diversion path provided by the RTR design.

The composition of the spent fuel causes fuel rod fabrication to be far more complicated and expensive. The necessity of the additional enrichment of the mixture of uranium isotopes will be extremely inefficient due to its isotopic composition. An attempt to separate U-233 from U-238, U-236, and U-234 isotopes will also remove the fissile U-235 from the resulting enriched stream. In addition, the separation process involved in enriching the mixture of all uranium isotopes will also require a remote operation, due to high gamma radiation levels.

The RTR provides inherently elevated proliferation resistance in comparison with a standard LWR of current technology. The comparative analysis shows that the RTR spent fuel stockpile will produce significantly reduced amounts of fissile material, the produced material will be more resistant to separation and diversion, and of a significantly lower weapon grade quality.

CONCLUSION

The NPT obligates the United States to transfer to other countries, particularly developing countries, peaceful nuclear energy technology. The NPT provides no guidance as to what constitutes peaceful nuclear energy technology. The RTR is the only system which can be used to modify existing nuclear power plants to make them unable to produce nuclear weapons-suitable materials. If any nuclear energy technology can be considered to be "peaceful," it is the RTR.

The RTR provides a new and meaningful addition to the requirement that the technology to be transferred is truly "peaceful." The RTR helps to sever the link between nuclear power generation and nuclear weapons. "Peaceful" can mean more than the IAEA safeguards regime assurances that spent nuclear power plant fuel rods are not used to produce nuclear weapons; "peaceful" now can mean that the technology has rendered nuclear power plants unable to produce materials that are suitable for use in nuclear weapons. The RTR is undergoing testing and is expected to be ready for commercial use in the year 2000.