Three Barriers In The Nuclear Power Steeplechase
by Stuart R Butzier
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THREE BARRIERS IN THE NUCLEAR POWER STEEPLECHASE

INTRODUCTION[1]

In last year's nuclear power paper for this same energy conference, I likened this country's decades-old encounter with nuclear power to a love-hate relationship, and pointed out that such relationships, while invigorating, are not for the faint of heart. The paper summarized a number of the favorable factors that seemed (and certainly continue) to be aligning and conveying us headlong toward a nuclear resurgence.[2] The paper also outlined—in less detail—several of the significant and high-profile challenges facing the nuclear energy industry in the United States.

This year's paper offers an examination of three of the most challenging barriers that ultimately need to be cleared if the nuclear industry hopes to realize the promise of a nuclear energy renaissance that so many experts are predicting. The first issue discussed is the controversial dilemma of what to do about the wastes that are attendant to generating electricity through the development and harnessing of nuclear energy. The next issue is the high costs, timing uncertainties, and liability potential for those companies and consortia that are best positioned to actually invest in the new generation of nuclear power undertakings within the United States. The last issue is the nagging relationship between nuclear power generation and the popular concerns with nuclear proliferation.

All three of these barriers in one way or another come down to fear: fear of the health and safety aspects of radioactive waste handling, storage and/or disposal; fear of financial investment uncertainties; and fear that nuclear weapons capacity might get into the wrong hands. Unfortunately, while such fears can blind us to the benefits of nuclear technologies, they cannot be as easily dismissed as President Franklin D. Roosevelt did with his eloquent urgings that helped this country rise above the Great Depression. The nuclear power conundrums examined in this paper exist tangibly in our path, like the stationary barriers in an Olympic steeplechase event. The overarching question is whether and how they might be overcome so that we might ultimately endure the run to celebrate along with the considerable talent from the rest of the industrialized and developing world.

I. THE NUCLEAR WASTE BARRIER

To begin to get one's arms around the problem of nuclear waste and to provide context, it is important to have at least a basic working understanding of the nuclear cycle; the types and nature of materials and wastes produced in the course of producing fuels and generating nuclear power; the hazards the wastes pose; the basic legal frameworks currently in place that purport to address them, and the allocation of responsibilities for their handling, storage and disposal. The sections below briefly attempt to provide some of this basic context.

A. The Nuclear Cycle

Because of the way in which materials within the nuclear industry are categorized and regulated under United States law (as summarized in the next section of this paper below), it may be useful to think of the nuclear cycle as really involving two relatively distinct cycles, the nuclear fuel cycle and the nuclear power cycle. These cycles, which roughly correspond to the supply versus the use phases of nuclear fuel, result in various waste products of varying concern depending primarily on their range of radioactive qualities, the duration of their half-lives resulting from radiological decays, and their potential for use or further development into materials for use in power stations or in nuclear weapons.

At the outset, the nuclear fuel cycle traditionally begins with the mining of uranium, a fairly ubiquitous mineral that exists in large quantities in the western and southwestern part of the United States, as well as in Canada, Australia, Argentina, Brazil, South Africa, Namibia, Niger, China, certain republics of the former Soviet Union, and no doubt several other countries around the world. After the uranium is mined, it is milled to separate out the uranium values from waste rock ores, which become tailings.[3] The recovered uranium takes the form of a chemical compound of uranium and oxygen (U3O8) that is commonly referred to in the industry as “yellowcake.” Yellowcake largely is comprised of a small quantity (0.7 percent) of U-235, which is an isotope capable of nuclear fission, and the much more naturally abundant U-238, a non-fissile isotope.

Once in the form of yellowcake, the material is either processed chemically for direct use in certain types of nuclear reactors, such as the heavy-water CANDU design popular in Canada, or further enriched for use in light-water reactors such as those employed in the United States. Enrichment at this stage essentially involves one of two processes designed to increase the concentration of fissile U-235 material relative to the non-fissile U-238. The first and currently most common practice is a gaseous diffusion process, which involves adding fluorine to the uranium to convert it to uranium hexafluoride gas (UF6), and then introducing the gas into a system of membranes through which the slightly lighter molecules containing U-235 somewhat more readily pass. The second enrichment process, which is gaining in popularity, is the process of drawing off some of the heavier material, i.e., the U-238 isotope, by use of high-speed centrifuge technology. The goal of enrichment generally is to increase from its natural level of approximately 0.7 percent to over 3 percent the amount of fissile U-235 relative to the inert U-238. The resulting enriched material, sometimes referred as “low enriched material,” or “LEU,” can be used more efficiently in the process of nuclear fission than the direct use of U308 (or the use of only slightly enriched uranium, known as “SEU”).

Before placement in reactors, both yellowcake used in its non-enriched form in heavy-water reactors, and enriched uranium used in light-water reactors, are fabricated into small pellets[4] that are combined in rows within zirconium-alloy tubes to form the fuel rods that are used as the fissionable fuel source in the core of nuclear reactors. In the reactor core, the fissile U-235 material undergoes fission in a controlled, chain-reaction environment, producing energy that ultimately heats water into the steam that turns the turbines for the large-scale generation of electricity.

The use of fabricated fuel rods as the vehicle for chain reactions in the energy power cycle fundamentally changes the makeup of the fuel rods themselves. Specifically, the splitting of the fissile U-235 material depletes most of the U-235 isotope, and transforms (by the addition of neutrons resulting from fission) a portion of the U-238 into plutonium (most notably Pu-239) and other heavy transuranic isotopes (meaning isotopes that have an atomic number “beyond uranium,” i.e., heavy materials not found in nature and having a larger atomic number than naturally occurring U-238[5]). Of particular note in this isotopic mix is the presence of plutonium-239, itself a highly fissile material that can be used in the further generation of nuclear power, or in certain nuclear medicine applications, or in the development of nuclear bombs (either in a “dirty” mixture with other non-fissile transuranics or by itself in purer plutonium weaponry having a much greater yield).

Because Pu-239 is an isotope that has tremendous energy generation capacity due to its highly fissile nature, many nuclear advocates promote the very expensive reprocessing of spent nuclear fuel rods to capture the newly created Pu-239 in addition to any remaining U-235 fissile materials not depleted in the reactors. Whether reprocessing of spent fuel is something that should be pursued in the United States given our ready supply of uranium reserves, is a complex question at the intersection of science, economics, politics, domestic security and international relations that has spawned significant debate. Although no reprocessing plants currently are permitted or in use in the United States, they exist in certain other countries.

In addition to uranium pellets containing 0.7 percent or the 3-plus percent U-235 derived from the processing or enrichment of traditionally mined uranium into LEU, some nuclear reactor designs that are presently in use and being constructed in other countries today are capable of handling more concentrated nuclear energy resources. Such designs are capable of producing tremendous amounts of energy from very small volumes of materials by making secondary use of P-239 derived from spent fuels, other fissile plutonium, highly enriched uranium (i.e., "HEU," where the U-235 concentration typically is 20% or higher) derived from dismantled nuclear weapons, and mixed fuels consisting of plutonium down-mixed with oxides (known as MOX fuel).

B. The Existing Legal Framework

The key laws governing the nuclear fuel and nuclear power cycles are federal statutory laws and federal regulations adopted pursuant to those statutes. The most notable statutory laws bearing on nuclear facility and attendant waste issues are the Atomic Energy Act ("AEA") of 1954, 42 U.S.C. §§ 2011, *et seq.*; the Uranium Mill Tailings Radiation Control Act ("UMTRCA") of 1978 (amending the AEA), and the Nuclear Waste Policy Act of 1982, 42 U.S.C. §§ 10101, *et seq*. Relevant portions of each of these and some of the regulatory programs under them are briefly highlighted here. Three other important federal laws, the Price-Anderson Act of 1957, the Energy Policy Act of 2005, and the Nuclear Nonproliferation Act of 1978, are reserved for the discussions of the investment uncertainties and nuclear nonproliferation issues appearing later in this paper.

1. The Atomic Energy Act of 1954

Adopted in the wake of President Dwight D. Eisenhower's visionary "Atoms for Peace" speech to the United Nations in 1953 following the devastating end of World War II, the AEA provided Congress' program "to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public." 42 U.S.C. § 2013(d). By the AEA, Congress also sought to promote "international cooperation . . . and to make available to cooperating nations the benefits of peaceful applications of atomic energy as widely as expanding technology and considerations of the common defense and security will permit." 42 U.S.C. § 2013(e).

The AEA vested the Atomic Energy Commission—later renamed the Nuclear Energy Commission ("NRC")—with authority to control "the possession, use, and production of atomic energy and special nuclear material, whether owned by the Government or others . . . ." 42 U.S.C. § 2013(c). The "special nuclear material" referred to in this passage is one of three important statutory categories of materials addressed by the AEA, as follows:

- ***Source Material***, defined to include uranium and thorium and ores containing uranium or thorium over a certain concentration as set forth in regulations of the NRC. *See* 42 U.S.C. § 2014(z); 10 CFR § 20.1003.

- ***Special Nuclear Material***, defined to include plutonium and uranium that has been enriched, for example, in the U-235 isotope, as well as any material artificially enriched by the foregoing, but it does not include source material. *See* 42 U.S.C. § 2014(aa); 10 CFR § 20.1003.

- ***Byproduct Material***, originally defined to include radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material. *See* 42 U.S.C. § 2014(e); 10 CFR § 20.1003. As discussed below, tailings and other wastes produced from the milling or other processing of ores for their source material content were later included as "byproduct material" pursuant to UMTRCA.

Several provisions of the AEA authorized the Commission to license the domestic handling, and to control the domestic distribution and foreign distribution (in conjunction with Congress) of, source material, special nuclear material, and byproduct material. *See generally* 42 U.S.C. §§ 2091-2099 (source material program), §§ 2071-2078 (special nuclear material program), *and* §§ 2111-2114 (byproduct material program). Through extensive regulations, the NRC has expanded on these programs in substantial detail. *See*, *e.g.*, 10 CFR Parts 2 (domestic licensing procedures), 11 (eligibility criteria for accessing or controlling special nuclear material), (general and specific licenses for byproduct material), 40 (domestic licensing of source material),[6] *and* 50 (performance-based licensing of the construction, use and decommissioning of nuclear reactors and plutonium production facilities).

Significantly, pursuant to the AEA and the Energy Reorganization Act of 1974, the NRC has adopted detailed and technical standards for protection of workers and the public against radiation resulting from activities conducted under NRC-issued licenses. *See* 10 CFR Part 20. Among other things, these provisions establish health-based dose limits for exposure to airborne radioactive materials and residual radioactive exposures to licensed source, special nuclear and byproduct material and certain other materials, and the NRC is equipped with civil and criminal enforcement remedies for violations. *See*, *e.g.*, 10 CFP §§ 19.30 and 19.40.

In sum, pursuant to the AEA as it was originally adopted, among other things, essentially all facilities involved in the milling, enrichment and fabrication of nuclear fuel products, the use of such products in the generation of nuclear power, or the reprocessing of spent nuclear fuel to recover additional fissile materials, were tightly controlled by the predecessor of NRC, and those facilities remain under NRC's regulatory authority today. Initially, the AEA did not grant authority to the NRC to regulate the actual mining of uranium ores, nor to control uranium and thorium mill tailings once yellowcake was milled out of those ores. Insofar as mill tailings are concerned, however, that situation changed in 1978 due to concerns with the mildly radioactive nature of such tailings.

2. The Uranium Mill Tailings Radiation Control Act of 1978

For some time prior to passage of UMTRCA's amendments to the AEA in 1978, the NRC and its predecessor met emerging concerns with radon emissions from uranium and thorium mill tailings, and the early use of such tailings in construction materials, by asserting authority to regulate tailings under the broad authority granted by the AEA as well as under the National Environmental Policy Act of 1969 ("NEPA"). However, federal cases decided under NEPA found NEPA to be a procedural statute that does not serve to broaden a federal agency's substantive powers beyond the scope of regulatory jurisdiction granted by the agency's organic statute. This left NRC without authority to regulate uranium and thorium mill tailings and the associated environmental hazards posed largely by the relatively low level, but long-term radon emissions from tailings.

Accordingly, in 1978, Congress passed UMTRCA to provide express statutory authorization to regulate the production, containment and monitoring of uranium and thorium mill tailings. Under UMTRCA, Congress created what has come to be known as "section 11e(2) byproduct material," defined as "the tailings or wastes produced by the extraction or concentration of uranium and thorium from any ore processed primarily for its source material content." *See* 42 U.S.C. § 2014(e)(2); 10 CFR § 20.1003. Pursuant to Congress' new grant of authority, NRC was given licensing authority over mill tailings facilities and could impose its health-based radiological standards on operators.

The UMTRCA amendments added a couple of twists to the regulatory environment for § 11e(2) byproduct material, however. First, Congress did not just grant authority to the NRC; it also allocated certain authority to both the Environmental Protection Agency ("EPA") and the Department of Energy ("DOE"). For its part, the EPA received partially overlapping authority to develop generally applicable standards for protection against both radiological and non-radiological hazards associated with tailings and other milling wastes. *See* 42 U.S.C. § 2022(b).[7] Meanwhile, DOE was authorized, among other things, to enter into cooperative agreements with States for the remediation of inactive tailings ("Title I") sites—with NRC's oncurrence—to EPA's standards. *See* 42 U.S.C. § 7918. A similarly complex, although slightly different, tripartite regulatory scheme involving the same three agencies was established for active tailings ("Title II") sites.

Second, UMTRCA established a rather unique and creative requirement that, given the long-term hazards associated with mill tailings, following remediation of inactive sites both the § 11e(2) byproduct material and the land where it is deposited are to be transferred to the federal government or the State (at the State's option) for long-term surveillance and monitoring, unless NRC determines that such a disposition is not necessary or desirable to protect the public. *See* 42 U.S.C. § 2113, *et seq*. Upon transfer of mill tailings sites to the federal government, DOE is responsible to maintain the sites in perpetuity pursuant to an NRC license. *See* 42 U.S.C. § 7914; 10 CFR § 40.28.[8]

Pursuant to its authority to set standards for radiological hazards associated with § 11e(2) byproduct material, the EPA has adopted detailed technical standards for both active and inactive tailings sites to address radon emissions, to address radium 226 in soils, and to impose primary design standards and secondary performance standards. The primary design standards, for example, require lining of new tailings impoundments and extensions of existing impoundments. The secondary performance standards require compliance with numeric standards, generally derived from federal standards under the Safe Drinking Water Act, at points of compliance downgradient from the toes of uranium or thorium tailings impoundments in order to sufficiently control and prevent public exposure to the § 11e(2) byproduct material. In addition, where groundwater standards are not achievable, the licensee of a mill tailings facility may seek a site-specific alternative concentration limit ("ACL") based upon a risk-based assessment and showing that contaminant concentrations at the POC will be protective of public health and safety at any point of exposure ("POE").

In sum, UMTRCA effectively, albeit in somewhat complicated fashion, closed the statutory/regulatory gap that existed before the NRC had any authority over uranium and thorium mill tailings. Before and after UMTRCA, however, an emerging problem was developing and has been steadily increasing from the generation of more highly radioactive wastes resulting from the nuclear cycle. Although scientist have devoted considerable time and energy on the question of what to do with such wastes, and while pragmatic solutions have been offered, the practical, economic, political and legal realities have plagued the industry and general public with inertia over such wastes.

3. The Nuclear Waste Policy Act of 1982

The AEA's licensing regime and original definition of "byproduct material" theoretically established the authority of NRC's predecessor agency to exercise jurisdiction and control over facilities for the storage or disposal of wastes such as spent fuel rods or other high-level radioactive wastes generated from nuclear reactor or enrichment facilities. Despite this, and although the AEA sought as one of its goals to promote privatization of virtually all things nuclear, the AEA did nothing of any consequence to encourage the actual development of private nuclear waste facilities beyond retaining the flexibility for research and development into potentially appropriate means of storage and disposal. As a result, no such facilities were constructed, and the NRC instead engaged in the practice of permitting interim storage of such wastes at the locations of the reactor facilities themselves. That set of circumstances exists to this day.

Following adoption of the AEA, an initial feeble attempt by Congress to address the high-level nuclear reactor waste situation came in the form of an act authorizing appropriations to the NRC for fiscal year 1979. In that act, Congress passively invited anyone proposing to develop a storage or disposal facility for spent fuels and other nuclear wastes to notify the NRC of those plans, in which case NRC would have to notify the Governor and State legislature in question of the plans. *See* 42 U.S.C. § 2021a(a). The appropriations act then provided an opportunity for the State to review any such proposal and set forth various means to improve the State's opportunities for participation in the process of siting, licensing and development of the invited proposal. 42 U.S.C. § 2021a(b). Perhaps not surprisingly, there is no indication that any promising storage or disposal facilities surfaced beyond the de facto interim storage facilities located at the licensed reactor facilities.

By 1982, when Congress passed the Nuclear Waste Policy Act, it expressly set forth its rationale for a new and more aggressive approach to the problem, finding that:

(1) radioactive waste creates potential risks and requires safe and environmentally acceptable methods of disposal;

(2) a national problem has been created by the accumulation of (A) spent nuclear fuel from nuclear reactors; and (B) radioactive waste from (i) reprocessing of spent nuclear fuel [among other sources];

(3) Federal efforts during the past 30 years to devise a permanent solution to the problems of civilian radioactive waste disposal have not been adequate;

(4) while the Federal Government has the responsibility for the permanent disposal of high-level radioactive waste and . . . spent fuel . . . in order to protect the public . . . , the costs of such disposal should be the responsibility of the generators and owners of such waste and spent fuel;

(5) the generators and owners [also have] the primary responsibility to provide for . . . and pay costs of . . . interim storage of such waste and spent fuel until [it] is accepted by the Secretary of Energy in accordance with this section;

(6) State and public participation in the planning and development of repositories is essential in order to promote public confidence in the safety of disposal of such waste and spent fuel; and

(7) high-level radioactive waste and spent nuclear fuel have become major subjects of public concern, and appropriate precautions must be taken to ensure that such waste and spent fuel do not adversely affect the public health and safety and the environment for this or future generations.

42 U.S.C. § 10131(a).

As these findings suggest, the Nuclear Waste Policy Act placed the responsibility on the federal government (through several agencies, and with the involvement of interested Governors) to establish guidelines for the identification and evaluation of candidate sites and the nomination of candidate sites by DOE. 42 U.S.C. § 10132. The act specifically provided for a NEPA-style environmental assessment to be performed by DOE for each nominated site, but provided that NEPA itself did not apply until actual nomination of a site to the President by the DOE. *Id*.; *and see* 42 U.S.C. § 10134(f).

The Nuclear Waste Policy Act also defined some additional categories of materials that need to be added on top of the AEA's use of source, nuclear and byproduct material. The Nuclear Waste Policy Act added these terms for various nuclear materials:

- ***Spent Nuclear Fuel***, defined to include fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. *See* 42 U.S.C. § 10101(23).
- ***Transuranic Waste***, defined to include material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium in certain concentrations. *See* 42 U.S.C. § 2014(ee).
- ***High-Level Radioactive Waste***, defined to include the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient quantities. *See* 42 U.S.C. § 10101(12)(A).
- ***Low-Level Radioactive Waste***, defined to include radioactive material that is not high-level radioactive waste, spent nuclear fuel or byproduct material, and that the NRC classifies as low-level radioactive waste. *See* 42 U.S.C § 10101(16).

These terms are principally employed by the Act's provisions relating to the specifics of how these various materials are to be disposed of, either permanently, on interim bases, and/or in "monitored retrievable storage facilities." The details of those provisions are beyond the scope of this paper, but the newly introduced terminology is helpful both to an understanding of the Yucca Mountain repository, discussed next, and to the discussion of nonproliferation issues in the last part of this paper.

C. The Decades-Old Yucca Mountain Quagmire—Yuk!—What Now?

Through extensive scientific study and the processes established by Congress under the Nuclear Waste Policy Act of 1982, within five years of that Act the Yucca Mountain site in Nevada emerged as DOE's nominated site for the first permanent repository for spent nuclear fuel and high-level radioactive waste. *See* 42 U.S.C. §§ 10133-1036 (setting forth 1987 amendments that established procedures for the site characterization of; state and public participation in public hearings on; site approval and construction authorization for; obtaining a Congressional resolution concerning; and provisions for DOE grants to Nevada and any affected unit of local government to ensure meaningful review and evaluation of, DOE's Yucca Mountain site proposal.) DOE recommended Yucca Mountain on May 27, 1986, over twenty years ago.

For the intervening twenty years since Yucca Mountain emerged as DOE's favored site, however, the site's ultimate commissioning and operation as a repository repeatedly has gotten bogged down in a series of highly charged debates that have raged on within various political, aministrative, scientific/academic and litigation milieus.[9] Meanwhile, as recently pointed out by an interdisciplinary MIT study, The Future of Nuclear Energy, (2003), "[f]or fifteen years the U.S. high-level waste management program has focused almost exclusively on the site at Yucca Mountain in Nevada." *Id*. at p. 10. As for Yucca Mountain, the interdisciplinary team of MIT scientists "concur with the many independent expert reviews . . . that geologic repositories will be capable of safely isolating the waste from the biosphere [and that] the successful commissioning of the Yucca Mountain repository would be a significant step towards the secure disposal of nuclear waste . . . ." *Id*.

It is widely understood, however, that even if Yucca Mountain were commissioned and made operational tomorrow, its capacity would be filled by the wastes already accumulated in the interim disposal facilities that NRC has permitted utilities to keep on-site at their nuclear power stations. Accordingly, Yucca Mountain would provide some relief from mounting spent fuel wastes, but that would do little to address the wastes anticipated to be generated by the expansion of nuclear power capacity to help meet rising energy demands domestically and worldwide.

Although both the President and Congress (in 2002) have now approved of the Yucca Mountain repository, the site still has not been successfully licensed. In a May 2006 Senate Energy Committee hearing, several Senators expressed their exasperation over DOE's inability to get the job done and the continuing regulatory delays preventing the shipment of nuclear wastes to the facility. Significantly, however, the Chair of the Committee, New Mexico Senator Peter Domenici, took the opportunity to disclose that a bill is being drafted that may alter Congress' goals for Yucca Mountain to allow for reprocessing of the spent fuel rods for secondary recovery of fissionable products before remaining wastes are placed in the respository. It also came up in the May 2006 hearing that DOE is evaluating other sites (whether as alternatives to or in addition to Yucca Mountain is unclear) for usefulness as interim storage sites.

D. Broader Consideration of Waste Disposal Methods

In his well-written book, Nuclear Choices (1993), Professor Richard Wolfson provided a helpful summary of several options for disposal that by then had received at least some consideration within the business, governmental and scientific communities. The options considered include:

- Launching waste into space, either in distant orbits about the Sun or the Earth or into the Sun

- Burial in thick sediment layers below the ocean bottom.
- Allowing hot wastes to melt their way into or through the 2-mile thick ice sheets of Greenland and Antartica.
- Disposal in very deep holes, about 4 miles below the Earth's surface.
- Disposal at modest depths (about ½ mile) in geologically stable rock formations free from contact with groundwater. (As at Yucca Mountain).
- Transmutation of waste to shorter-lived isotopes that decay rapidly.
- Disposal in salt domes—huge underground deposits of naturally occurring rock salt.

Id. at pp. 228-229. Professor Wolfson discusses some pros and cons associated with these options, and although he leaves the ultimate conclusions to the reader, he seems to suggest that the geologic disposal options at modest and deep depths are the most promising options presently.

Similar conclusions are drawn in the MIT study. In addition to endorsing the idea of disposing of nuclear wastes in geologically stable rock, as at Yucca Mountain, MIT's team of scientists made the following waste management recommendations:

- The DOE should augment its current focus on Yucca Mountain with a balanced long-term waste management R&D program.
- A research program should be launched to determine the viability of geologic disposal in deep boreholes within a decade.
- A network of centralized facilities for storing spent fuel for several decades should be established in the U.S. and internationally.

Nuclear Choices, at p. 11.

E. <u>Further Thoughts on the Nuclear Waste Dilemma</u>

One thing is clear about the nuclear waste dilemma: it is not going away anytime soon, and the challenge may be to intelligently manage the dilemma over time rather than permanently solve it. Nor is there an end in sight to the accumulation of mountains of scientific studies of the waste problem and the associated potential for, and possible desirability of, reprocessing nuclear waste (an open-ended and hotly debated question[10] that may make shallow geologic disposal more attractive than less retrievable forms of disposal). Because a significant component of the reprocessing debate involves nonproliferation concerns, discussion of that topic is reserved for the last issue addressed in this paper.

An important lesson from the long-standing Yucca Mountain experience, it seems, is that the nuclear waste disposal dilemma cannot be solved by science alone. After all, the credible, peer-reviewed science appears to be in that disposal of nuclear wastes at Yucca Mountain would be adequately protective of the biosphere, yet commissioning of the site has proven elusive. As important as the input of science now, herefore, is the thoughtful reevaluation of the failed legal and regulatory process. Also needed is the persuasive force of advocates, whether from industry,[11] the government,[12] the legal arena or the general public, to effectively convey that we need to promptly break through the nuclear waste impasse, even if only on an interim basis, to allow the scientists and engineers time and space to develop even more technologically innovative solutions, as they likely will.

II. INVESTMENT COSTS, TIMING AND LIABILITY BARRIERS

One southwestern utility executive recently pointed out that financing the high construction costs of new nuclear facilities will be key, and publicly asserted that "[n]o CEO is going to bet his or her company on a new nuclear unit."[13] Certainly the challenges and uncertainties associated with costs and delays in permitting and construction of expensive new nuclear facilities are daunting, the Yucca Mountain experience being just one convenient example. Cost estimates for licensing, permitting, siting, construction loan interest, etc., has been as high as $2320 per kilowatt.[14] In addition, liability risks can be significant in an industry built on harnessing nuclear power and handling special nuclear materials, spent fuels, high-level radioactive wastes, transuranics and other byproduct materials, all of which pose radiological hazards in the event of accidents or unfortunate events that history has proven can indeed happen.

A. Price-Anderson Act Extended to 2025

Some protection against the risk of liability exposure is afforded by the Price-Anderson Act of 1957. *See* 42 U.S.C. § 2210 and 2211. Price-Anderson was originally enacted when nuclear technologies were so new and uncertain that insurance companies balked at providing insurance to the industry, but its provisions remain important to the industry.

Among other things, Price-Anderson: (a) limits liability for nuclear incidents resulting from operation of federally licensed private nuclear power plants; (b) establishes a regime of no-fault insurance coverage for the public in the event of a nuclear incident; and (c) provides certain indemnification opportunities associated with conducting licensed activities. Fortunately for the nuclear power industry, Price-Anderson was just extended through 2025 by the Energy Policy Act of 2005.

B. The Energy Policy Act of 2005

The Energy Policy Act of 2005, in addition to extending Price-Anderson, did several fairly significant things to provide incentives for the construction of advanced nuclear power plants. *See generally* M. Herlach and K. Zeswitz, "Nukes Ride Again; the Energy Policy Act Returns Nuclear Energy to Center Stage," Nuclear Energy (January 1, 2006).

First, the Energy Policy Act provides "standby support" for construction of an "advanced nuclear facility" to address a common complaint from the industry about delays in the processes associated with licensing and permitting of facilities. Under these provisions, financial losses are covered for certain NRC-caused delays and for any operational delays resulting from litigation. Covered costs include, importantly, any principle or interest on project debts and delay-based costs of having to purchase power on the market to meet electricity supply contracts.

Second, the Act provides for certain loan guarantees which DOE may extend for up to 80 percent of project costs for a broad range of technologies—including advanced nuclear facilities—that reduce greenhouse gas emissions.

Third, the Act makes qualifying advanced nuclear power facilities eligible for production tax credits starting at 1.8 cents per kilowatt-hour of electricity generation. Meeting the eligibility for the tax credits, however, can be tricky.

Fourth, the Act improves upon special tax incentives that were originally adopted in 1984 relating to the utilities' setting aside of reserve funding for the decommissioning of facilities. Specifically, the Act now allows a tax deduction for reserve fund set-asides sufficient to cover the present value of 100% of projected decommissioning costs.

Last, but not least, the Act contains an array of provisions offering billions of dollars of support for nuclear and hydrogen energy research and development. The provisions, for example, encourage a Generation IV Nuclear Energy System Initiative to develop promising new reactor designs for commercial application. Other provisions authorize funding for DOE's Nuclear Power 2010 program and provide cost sharing programs to encourage the construction of new plants. Still other provisions direct DOE to pursue a broad-ranging study of the reliability and security of existing nuclear plants.

C. Promising Signs Among Energy Consortia and Joint Ventures

Despite the reluctance of individual executives to “bet the company” on new power units, the Energy Policy Act incentives and relatively favorable overall climate for nuclear energy appear to be spurring groups within the industry into action. *See id*. NuStart Energy, for example, which is the largest consortium under DOE’s Nuclear Power 2010 program, reportedly has already selected two sites for advanced nuclear reactors designed, respectively, by Westinghouse and General Electric. Other utilities and recently-formed joined ventures, such as UniStar Nuclear, are also moving toward licensing and construction of other advanced nuclear reactor designs.

Closer to home here in New Mexico, the international LES consortium is on an NRC licensing and plant construction schedule that will soon place the first centrifuge-based uranium enrichment plant in the United States. At least initially, the plant will produce LEU materials that will be ready for fabrication into pellets for insertion into fuel rod assemblies.

III. THE NUCLEAR PROLIFERATION BARRIER

Perhaps never since the height of the Cold War has there been greater or more justified concern about nuclear weapons getting into the wrong hands than there is today. To better understand how the renewed global enthusiasm for nuclear power plays into that concern, it is necessary to return to the basic types of nuclear processes and materials which directly or indirectly might lead a nation or group of determined individuals on the path to nuclear weapons capability. It is also important to examine the international nonproliferation regime, or at least what may be left of it, as well as the United States’ role and goals within it. Finally, it is useful to evaluate some of the lines of debate and proposals for addressing nonproliferation that are on the table. Each of these matters are addressed in turn below.

A. Nuclear Energy Processes and Materials With Proliferation Implications[15]

Much of the renewed concerns with nuclear proliferation relates to what UN Secretary General Kofi Annan aptly described as the “Janus-like character of nuclear energy.”[16] Nuclear reactors bring exceptionally high benefits to society in the form of prolific outputs of energy, as well as medical and other research benefits, but they also generate plutonium that can be made into high-yield bombs. Spent nuclear fuel can be reprocessed in very sophisticated, costly facilities to separate out pure plutonium-239 from other high-level radioactive wastes. Pu-239 is the highly fissile material of greatest concern since an easily engineered bomb containing it would have a particularly devastating nuclear yield. Accordingly, both Pu-239 and reprocessing facilities capable of separating Pu-239 from spent fuels present a relatively high proliferation concern.

Even spent nuclear fuel that has not been reprocessed can be fashioned into high-yield nuclear bombs where, as in CANDU reactors, fuel rods are frequently changed before the Pu-239 becomes substantially mixed with other heavy isotopes. Moreover, even the radioactive materials mix resulting from the longer uses of fuel rods in light-water reactors can be used in nuclear bombs, although they would be less powerful bombs since some of the mixture would be inert materials. Accordingly, spent nuclear fuel presents a fairly high proliferation concern, and heavy-water and light-water reactors present similar proliferation concerns, with the CANDU design presently a slightly greater proliferation risk as between the two designs.

Enriched uranium, particularly HEU (with 10% or more of U-235), and less so LEU (with 3% or more of U-235) also pose a proliferation risk, particularly if they get into the hands of nations with the technology to further enrich them or if they are using the materials in reactors. As between the common types of enrichment facilities, slightly greater risks are presented by centrifuge technology than gaseous diffusion technology since the former can more readily be used to develop HEU.

The mining and milling of uranium ores into yellowcake, as well as the uranium, yellowcake and 11e(2) byproduct materials (tailings), generally are not perceived to present a significant proliferation risk in and of themselves since so much more would have to happen before the materials could pose a significant nuclear threat. Nor would inert materials such as U-238 in and of themselves be a significant proliferation risk, although the presence of U-238 in a reactor core is ready to accept neutrons and be transformed into Pu-229.

Of particular concern are the special reactor designs that are capable of using Pu-239 as the direct, primary fuel source. The concerns with these designs are twofold. First, such reactors actually breed more plutonium than they use. Second, if put into the wrong hands, the reactors are inherently more dangerous if not operated properly. Similar concerns have been voiced about reactors that use fuel in the form of plutonium or HEU mixed with other uranium ("MOX" fuels).

In summary, the materials and facility technologies from the nuclear fuel cycle discussed above, and a few others, are listed below in roughly descending order of nuclear proliferation risk (from relatively high to virtually no risk at all), as follows:

- Plutonium-239 (Pu-239)
- Reprocessing facilities allowing separation of Pu-239
- Reactors designed to accept Pu-239 as a primary fuel source
- Uranium 235 (U-235)
- Reactors designed to accept HEU or MOX fuels
- Heavy-water CANDU reactors
- Light-water reactors
- Centrifuge enrichment technology
- Gaseous diffusion enrichment technology
- Fuel pellet and rod fabrication technology
- Yellowcake (U308)
- Mill tailings and mills
- Uranium ores and mining equipment

The higher the items appear on this list, the more discriminating and careful our government may want to be in sharing them with particular nations.

B. <u>The International and Domestic Nonproliferation Regime</u>

The centerpiece of international multilateral efforts to curb nuclear proliferation is the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (the "Nuclear Nonproliferation Treaty"). There are numerous other treaties, multilateral agreements, bilateral agreements, initiatives and arms accords that are beyond the scope of this discussion. Suffice it to say that the most significant framework for controlling proliferation over the last three and a half decades has been the 1968 Nuclear Nonproliferation Treaty, which became effective in 1970.

In a nutshell, all signatories to the Nuclear Nonproliferation Treaty except the United States, Russia, the United Kingdom, France and China renounced nuclear weapons, and all signatories including those five committed to collaborate on developing peaceful uses of nuclear energy. The International Atomic Energy Agency ("IAEA") has responsibility for verifying compliance with the Treaty insofar as fuel cycle facilities are concerned, and attempts to do so through negotiated safeguards agreements with signatories. The MIT authors of The Future of Nuclear Power, *supra*, have observed, however, that the IAEA's safeguard efforts have been "seriously constrained" by a number of factors, including the limited scope of its authority, the lack of sanctioning support by the United Nations Security Council, the lack of adequate resources and funding, and other such problems.

Further, not all nations are signatories to the Treaty. For example, neither India (with which a controversial bilateral Indo-U.S. nuclear energy agreement is pending), nor Pakistan are signatories, and both those countries now have nuclear weapons. In addition, even signatories that renounced nuclear weapons under the Treaty have since admitted to making nuclear weapons, including Isreal, South Africa and North Korea (North Korea since then withdrew from the Treaty in 2003).

The Nuclear Nonproliferation Treaty seemingly was strengthened in 1995 when 173 nations committed to reject nuclear weapons if the five declared nuclear weapons countries would eventually eliminate their arsenal. However, a decade has passed and the United States and United Kingdom, for example, are showing their intentions to be otherwise. See R. Edwards, *supra*.

C. The Domestic Legal Framework Bearing on Nonproliferation

1. The Atomic Energy Act of 1954

As has already been discussed under the first issue above, the AEA had as one of its central purposes "to make available to cooperating nations the benefits of peaceful applications of atomic energy as widely as expanding technology and considerations of the common defense and security will permit." 42 U.S.C. § 2013(e). DOE was also vested with authority, subject to Congressional approval, to develop international agreements to pursue these purposes. As an aside, it is not entirely clear how the United States' recent agreement to provide nuclear energy assistance to India comports with AEA's "cooperating nations" provision, inasmuch as India has never signed on to the Nuclear Nonproliferation Treaty.

2. The Nuclear Nonproliferation Act of 1978

Under the Nuclear Nonproliferation Act of 1978, Congress in fairly strong language appeared to commit the United States to a strengthening of international controls on energy-related proliferation, saying that the United States would "actively pursue through international initiatives mechanisms for fuel supply assurances and the establishment of more effective international controls over the transfer and use of nuclear materials and equipment and nuclear technology for peaceful purposes in order to prevent proliferation, including the establishment of common international sanctions." 22 U.S.C. § 3201(a). Congress also stated a policy to "cooperate with foreign nations in identifying and adapting suitable technologies for energy production." § 3201(d). A further goal was to "strongly encourage nations which have not ratified the [Nuclear Nonproliferation Treaty] to do so at the earliest possible date." § 3201(c).

There are some signs the United States has pursued these policy statements. For example, it has participated in such multilateral agreements as the Nuclear Supplier Group guidelines for export control, which had the purpose of restricting the spread of dual-use technologies and other technologies causing proliferation concerns. *See* MIT Study, *supra*, p. 65. On the other hand, the recent signing of an arrangement to provide India with nuclear energy capabilities, while perhaps pragmatic, seems inconsistent with the policy of encouragement to participate in the Treaty to which India has never been a signatory. Further, rightly or wrongly, the United States along with Iran has been accused of blocking agreements to control the production of HEU and plutonium, as well as "behind the scenes manipulations" to avoid "any outcome that would constrain their own nuclear options," according to Rebecca Johnson of the Institute for Disarmament Diplomacy in London. See R. Edwards, *supra*.

D. Proposals for Reconciling Nuclear Energy and Nonproliferation Goals

Much of the debate surrounding the intersection between nuclear energy and nonproliferation has centered, appropriately, on the reprocessing of spent nuclear fuels to separate out Plutonium 239 from the mix of high-level radioactive wastes captured within the spent fuel rods. Some have stridently advocated such reprocessing is the key to taking full advantage of the energy potential that can be recycled from spent fuels. *See*, *e.g.* Rhodes and Beller, *supra*. These authors argue that burying spent fuels without extracting its plutonium by reprocessing would actually increase the long-term risk of nuclear proliferation "since the decay of less-fissile and more-radioactive isotopes in spent fuel after one to three centuries improves the explosive qualities of the plutonium [and because] recycling would make it possible to convert plutonium to useful energy while breaking it down into shorter-lived, non-fissionable, non-threatening nuclear waste." *Id*.

The interdisciplinary MIT team presents another quite reasonable and promising view. They argue against reprocessing of spent fuels to recover pure plutonium for re-use, at least in the near term, based on a number of observations. First, and most obviously, the plutonium thus separated could too easily be converted to make nuclear bombs under the weak international safeguarding system currently in place. Second, reprocessing currently is unnecessary since natural uranium ore is available at reasonable prices to support nuclear energy through late in the century even under a substantial expansion scenario. Third, pursuing energy recovery from the plutonium content of spent fuels is something that can always be pursued later this century should uranium supply dwindle. Fourth, waiting to reprocess spent nuclear fuels would bring advantages from further opportunities to improve the science of reprocessing and employing plutonium in reactors, and to examine and shore up international institutional controls over nuclear proliferation. MIT Study, pp. 12-16 and 65-69.

Meanwhile, the Bush Administration has strongly pushed an agenda to pursue reprocessing technologies, but ones which do not produce separated plutonium and which in theory would be more proliferation resistant. *See* November 2005 Comments of Energy Secretary Sam Bodman to the Carnegie International Nonproliferation Conference, *reported in* "How Reprocessing and GNEP Are Designed to Work," The National Journal (May 6, 2006). The May 2001 National Energy Policy report of Vice President Cheney's controversial Energy Policy Task Force recommended searching for ways to electromagnetically extract useful material from spent nuclear fuel to reduce the amount of waste and discourage proliferation. The report also recommended international collaboration efforts with partners having developed fuel cycles "to develop reprocessing and fuel-treatment technologies that are cleaner, more efficient and more proliferation resistant." *Id*.

Out of these recommendations came the "Advanced Fuel Cycle Initiative" for domestic research into reprocessing of spent fuels, fabrication of fuels from the extracted products, and advanced reactor technologies to use such recycled fuel, as well as the "Global Nuclear Energy Partnership" that would expand the same initiatives globally. A centerpiece of these initiatives is the funding of reprocessing technology known as "UREX-plus," which essentially involves the recovery of uranium and plutonium from spent nuclear fuels, which then are mixed with other radioactive materials such as americium, neptium and curium, making the plutonium less pure and therefore less attractive (although probably still usable) for weapons purposes. *Id*.

One gaping uncertainty that arises from the Administration's pursuit of spent fuels reprocessing under these initiatives is how it will improve chances of international buy-in to nonproliferation. While the reprocessing being explored ultimately might prove viable and lessen the purity of spent fuels processed in that same fashion, it is not clear what international or institutional control mechanisms the Administration will be able to employ to ensure that processing elsewhere will be conducted in the same way (as opposed to ways already in use where the purer forms of extracted plutonium are being used). And if the proposed mechanism is to entice the advanced countries into a small club of nuclear technology suppliers to the rest of the world, what guarantees are there that that club will not exhibit the same kind of cartel-like behavior that partly impels our retreat from foreign oil dependency?

To fully realize the global promise of nuclear energy, the United States should: (1) examine ways to re-approach the international community in a spirit of magnanimity; (2) be prepared to loosen its own grip on nuclear weapons and materials; and (3) lead by example down the path to peaceful nuclear energy applications.[17] While tough international controls may be advisable to stem nuclear proliferation in the present global environment, a two-class system of nuclear haves and have nots may not be the way to go about it. Similar systems have left the Nuclear Nonproliferation Treaty flawed, and have lead to tension and conflict where the few hold the energy reigns for the many.

CONCLUSION

The three barriers to a nuclear energy resurgence discussed in this paper are not insignificant, but neither are they insurmountable. The United States and nuclear industry should approach these tough barriers head-on, but with flexibility and foresight not to lock in to particular approaches that cannot be adapted later on to changed circumstances and improved science. The United States should also fully examine its approach to the international community on these issues and renew its commitment to making nuclear energy work for the world's benefit. Any institutional nonproliferation controls advocated for other nations should be readily abided by ourselves or they likely will not work. With a healthy dose of introspection and the courage to clear these last barriers, we should be able to catch the second wind that is upon us.

ENDNOTES

1. The author gratefully acknowledges Michael Hamilton for his assistance in reearching and providing throughful insights on the issues addressed in this paper. Mr. Hamilton, a 2006 summer associate witht the Modrall Sperling Law Firm, is between his second and third years of law school at Stanford University.

2. The favorable factors discussed in last year's paper included: (1) recent environmental community endorsements of nuclear energy as one of the most promising means of limiting our generation of greenhouse gasses from burning fossil fuels; (2) positive projections of nuclear energy's growth potential from a number of notable experts; (3) the fine safety record of nuclear reactors within the domestic industry; (4) improved nuclear reactor design and efficiency; (5) increasing worldwide enthusiasm for nuclear energy; and (6) nuclear energy's improving outlook for economic feasibility. *See* S. Butzier, Miles from Three Miles Island; Warming to Nuclear Energy (2005).

3. The milling of uranium ores and generation of large volumes of tailings are necessary aspects of traditional surface and underground uranium mining methods. More modern *in situ* mining, which involves recovery of uranium from underground through the use of a complex series of injection and recovery wells, drastically reduces the displacement, crushing and disposal of ores.

4. According to Richard Wolfson, author of Nuclear Choices—A Citizen's Guide to Nuclear Technology (1997), at p. 219, one enriched uranium pellet that is 1/2 inch long and 1/3 inch in diameter contains the energy equivalent of 150 gallons of gasoline or a ton of coal. Wolfson also points out that a coal-burning electric power plant consumes many 110-car trainloads per week, whereas a comparable nuclear power plant requires only a few truckloads of uranium fuel in a year. *Id*. at 15. Correspondingly, the waste generated from a nuclear power plant over time is miniscule compared to waste emitted into the atmosphere from a coal-burning power plant during a comparable period.

5. Although transuranic wastes such as plutonium-240 are generally thought of as materials which are not naturally occurring, scientists generally agree that such materials once existed in the Earth's early history, but that their half-life is short enough that they have long since decayed into other

naturally occurring isotopes in the Earth's crust today.

6. Since *in situ* mining is becoming more prominent in the uranium recovery industry, *see supra* n. 3, it is worth noting that such operations will require both source material and byproduct material licensing under the AEA. The reason is that, unlike traditional uranium mining operations that extract ores from the ground and generally are not regulated by NRC, in situ recovery involves the creation of yellowcake and the processing of ores in place for the recovery of source materials from those ores. Accordingly, pursuant to the NRC's definitions of source and byproduct materials in 10 CFR §§ 20.1003 and 40.4, both types of licenses likely will be required to perform *in situ* recovery operations.

7. As to the non-radiological hazards of § 11e(2) byproduct material, EPA's generally applicable standards are to provide the same protections afforded under EPA's Resource Conservation and Recovery Act ("RCRA") standards. Since NRC has the mill tailings licensing authority under UMTRCA, however, although EPA's standards apply, EPA itself is without permitting authority over the tailings under RCRA by virtue of the express exemption of § 11e(2) byproduct material from RCRA's regulatory regime. *See* 40 CFR § 261.4. The EPA also does not have any permitting authority over uranium mill tailings under the Clean Water Act's Section 402 National Pollutant Elimination Discharge System ("NPDES") permitting program. *See Waste Action Project v. Dawn Min. Corp.*, 137 F.3d 1426 (9th Cir. 1998) (holding that uranium mill tailings have been held to not constitute "pollutants" for purposes of the Clean Water Act).

8. Uranium mill tailings sites transferred to the federal government and maintained by the DOE under UMTRCA have been expressly excluded from the reach of the broad environmental liability net of Congress' Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"). *See* 42 U.S.C. § 9601(22). This circumstance leaves DOE with sole responsibility, and liability, for such sites.

9. *See*, *e.g.*, *State of Nev. v. Watkins*, 943 F.2d 1080 (9th Cir. 1991) (detailing litigation over the adequacy of the environmental assessment for Yucca Mountain and the effect of the site assessment procedures under the Act); *State of Nev. v. U.S. Dept. of Energy*, 133 F.3d 1201 (9th Cir. 1998) (dismissing Nevada's claim that DOE improperly denied funding to local government units for the evaluation of DOE's Yucca Mountain site characterization activities); *Joint Resolution* at 116 Stat. 735 (containing Congressional approval of Yucca Mountain and referring to the Nevada Governor's April 8, 2002 notice of disapproval).

10. *See*, *e.g.*, "The Pros and Cons of Nuclear Fuel Recycling" in Science (December 7, 2001).

11. Craven Crowell, a former chairman of the Tennessee Valley Authority, astutely pointed out in a recent Public Utilities Fortnightly article ("What's Holding Back the Nuclear Renaissance" (April 2006)) that two things must happen for the next surge of nuclear construction to occur: first, Yucca Mountain must be resolved; second, the industry needs a strong and highly visible executive who will champion nuclear power—one who can articulate in plain English a compelling plan for addressing waste storage and license application challenges.

12. New Mexico Senator Peter Domenici, a strong advocate of nuclear energy, recently proposed sharing the burden among multiple smaller disposal sites around the country. Such a proposal may help diffuse the localized outcries over Yucca Mountain in Nevada, but then again it may just multiply the din. Other creative and reasonable proposal have been offered that are worth consideration, such as to provide some form of financial recompense or other incentives to states based on volumes of wastes the burden of which they are willing to shoulder.

13. *See* Edward Fox, "A Utility Look at Nuclear Power," Paper 1B, at p. 1, Special Institute on Uranium Exploration and Development (RMMLF 2006).

14. *Id*.

15. Several who have published comments on the relationship between nuclear energy and nuclear proliferation have pointed out that even if global nuclear energy pursuits were stopped in their tracks altogether, there would still be significant global weapons proliferation concerns arising, for example, from: (1) the sheer volume of enriched uranium and plutonium-grade material already spread among a great many nations; (2) research reactors for medical applications placed throughout the world as part of the Atoms for Peace program, including in many politically unstable locales; and (3) the fact that plutonium is fairly easily derived not only from certain nuclear technologies, but also from relatively uncontrolled wastes generated in coal-burning power plants. *See*, *e.g.*, R. Edwards, "60 Years On, Is the World Any Safer?," New Scientist (July 16, 2005) (pointing out that 1900 tonnes of highly enriched uranium (HEU) and 1855 tonnes of plutonium are known to be spread among 45 to 50 countries around the world); Statement of Sig Hecker, former Director of Los Alamos National Laboratory (observing risks associated with research reactors); R. Rhodes and D. Beller, "The Need for Nuclear Power," Foreign Affairs (Jan.-Feb. 2000) (pointing out that plutonium could be derived from the yearly output of uranium-235 released by a 1,000 MWe coal plant, estimated at 74 pounds).

16. Referring to the two-headed Roman God of gates and doors; *quoted in* R. Edwards, *supra*.

17. The late Senator J. William Fulbright observed that "[t]here are many respects in which America, if it can bring itself to act with the magnanimity and the empathy appropriate to its size and power, can be an intelligent example to the world," including by providing "material helpfulness without moral presumption in our relations with developing nations…." *See* Fulbright, <u>The Arrogance of Power</u> (1966). Finding the way to heed this call in the quest to level the global playing field through the promise of nuclear energy will be one of the trickiest, but most important, challenges we will face in the twenty-first century, and negotiating effective nonproliferation measures must be at the core of the United States' efforts. *See* also Domenici, <u>A Brighter Tomorrow; Fulfilling the Promise of Nuclear Energy</u> (2004) (touting nuclear energy as a tool for ensuring world economic fairness and stability).