GLOBAL WARMING V. NON-PROLIFERATION: THE TIME HAS COME FOR NATIONS TO REASSERT THEIR RIGHT TO PEACEFUL USE OF NUCLEAR ENERGY

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I. INTRODUCTION

On March 2, 2006, President George W. Bush and Prime Minister Manmohan Singh of India entered into a nuclear energy cooperation agreement[1] despite the fact that India is not a signatory to the Nuclear Nonproliferation Treaty (NPT).[2] The U.S.-India Civil Nuclear Cooperation Initiative, if approved, would submit fourteen of India's twenty-two nuclear reactors to regular inspections by the International Atomic Energy Commission (IAEA).[3] Additional concessions by India include the negotiation of additional protocols with the IAEA, implementation of tougher export controls on nuclear technology, refraining from nuclear testing, and adherence to the Missile Technology Control Regime.[4] In return, India will be given access to American nuclear technology markets and accommodation within the Nuclear Suppliers Group (NSG).[5] In short, the United States agreed to grant access to the nuclear technology club in exchange for India's efforts to become a responsible nuclear weapons state.

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1 Fact Sheet, U.S. Dept. of State, Bureau Pub. Aff., U.S.-India Civil Nuclear Cooperation Initiative (Mar. 9, 2006), http://www.state.gov/documents/organization/63007.pdf [hereinafter Fact Sheet].

2 Treaty on the Non-Proliferation of Nuclear Weapons, *opened for signature* July 1, 1968, 21 U.S.T. 483, T.I.A.S. No. 6839, 729 U.N.T.S. 161 (entered into force Mar. 5, 1970) [hereinafter NPT].

3 Fact Sheet, *supra* note 1.

4 *Id.* The Missile Technology Control Group is an informal association of developed countries that have agreed to prevent the proliferation of missile systems for delivery of weapons of mass destruction. The Missile Technology Control Regime, http://www.mtcr.info/english/index.html (last visited Feb. 20, 2007).

5 Fact Sheet, *supra* note 1. The Nuclear Suppliers Group is discussed in more detail *infra* Part II.B.

What is truly remarkable about the tentative agreement between the United States and India is that the former appears willing to abandon a fundamental tenet of the NPT—that signatory nations will refrain from transferring nuclear technology to states outside the safeguards of the NPT.[6] India, although agreeing to become at least partially subject to the safeguards of the IAEA, will be allowed to maintain eight secret reactors, presumably for furtherance of its nuclear weapons program.[7] Even more remarkable is that the United States appears to be recognizing India as a legitimate nuclear weapons state. Under the NPT, only those states that detonated a nuclear weapon before January 1, 1967, are recognized as nuclear weapons states.[8] India, which detonated its first nuclear weapon in 1974,[9] is forever banned from membership in the NPT unless it agrees to give up its nuclear weapons. The United States appears to believe that economic and political considerations necessitate recognizing and cooperating with India as a legitimate nuclear weapons state.[10]

What then are the policy considerations that have trumped the very real nonproliferation concerns embodied in the NPT? In its Fact Sheet, the U.S. Department of State gives four reasons to justify the U.S.-India Civil Nuclear Cooperation Initiative: to strengthen the U.S.-India strategic relationship, to provide economic opportunities to American firms, to help India meet its energy needs in an environmentally friendly manner, and to bring India back into the nuclear nonproliferation mainstream.[11] Note that nonproliferation rather than proliferation is seen as a consequence of the agreement. However, it is the third justification—that India's future energy needs should be met by nuclear energy—that is the starting point for this Comment. More generally, this Comment argues that, like India, every nation should reassert its right to peaceful use of nuclear energy. At the same time, nuclear powers like the United States, although mindful of the problem of nuclear proliferation, cannot ignore the substantial benefits of

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[6] NPT, *supra* note 2, art. III ¶ 2 ("Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this article").

[7] Fact Sheet, *supra* note 1.

[8] NPT, *supra* note 2, art. IX ¶ 3.

[9] GEORGE PERKOVICH, INDIA'S NUCLEAR BOMB: THE IMPACT ON GLOBAL PROLIFERATION 1-2 (1999).

[10] Fact Sheet, *supra* note 1.

[11] *Id.*

nuclear energy, particularly as a solution to the urgent problem of global warming.

Since Eisenhower's Atoms for Peace speech at the UN in 1953,[12] the peaceful use of nuclear energy has taken half a century of beatings from environmental groups and others concerned about reactor safety, waste disposal, and nuclear weapons proliferation. Now, as we enter a new century of global warming concerns, nuclear power proponents are beginning to make a comeback.[13] Old habits are hard to break, however, and many governments and NGOs are far from convinced of the advantages of nuclear energy.[14] Opponents of nuclear power point to the perceived drawbacks of nuclear waste, safety, and increased opportunity for development of nuclear weapons by non-nuclear states.[15] Given the looming crisis of global warming, attitudes about the relative merits of nuclear energy may have to change. As it stands, nuclear power is the only existing energy source that can be developed at a scale capable of meeting our increasing energy needs without contributing to the global warming problem.[16]

This Comment will argue that nations need to reassert their right to peaceful use of nuclear energy for the sake of mitigating the problem of global warming. Furthermore, nuclear non-proliferation concerns need not become a pretext for denying access to peaceful nuclear technology. Part II will discuss the history of the right to nuclear energy and its development as a principle of international law. Legal and diplomatic efforts to limit access by developing states to nuclear technology and materials will also be discussed. Part III explains the

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[12] President Dwight D. Eisenhower, Address before the General Assembly of the United Nations on Peaceful Uses of Atomic Energy, New York City, 1 PUB. PAPERS 813 (Dec. 8, 1953).

[13] *See, e.g.*, *MIT Study Sees Nuclear Power as Green Weapon against Global Warming*, PHYSICS TODAY, Dec. 2003, at 34, 34.

[14] Both Greenpeace and the Sierra Club take strong stances against increased use of nuclear energy. "Greenpeace has always fought—and will continue to fight—vigorously against nuclear power because it is an unacceptable risk to the environment and to humanity." Greenpeace Int'l, End the Nuclear Age, http://www.greenpeace.org/international/campaigns/nuclear (last visited Dec. 1, 2006). "The Sierra Club opposes the licensing, construction and operation of new nuclear reactors utilizing the fission process," Sierra Club, Conservation Policies: Nuclear Power, http://www.sierraclub.org/policy/conservation/nuc-power.asp (last visited Dec. 1, 2006), and believes that "nuclear power plants . . . should be dismantled and the sites restored 30 to 50 years after the plant has ceased operating." Sierra Club, Conservation Policies: Decommissioning Nuclear Reactors, http://www.sierraclub.org/policy/conservation/decom.asp (last visited Dec. 1, 2006). The negative response of some nations to nuclear energy is discussed *infra* Part III.B.

[15] *See, e.g.*, Greenpeace Int'l, *supra* note 14.

[16] Denis E. Beller, *Atomic Time Machines: Back to the Nuclear Future*, 24 J. LAND RESOURCES & ENVTL. L. 41, 42 (2004). Wind, solar, and hydroelectric energy, which also produce little or no carbon emission, suffer limitations that are discussed *infra* Part III.A.

renewed importance of nuclear energy in the context of the global warming debate. A comparison is made between the negative diplomatic response to nuclear energy in the Kyoto Protocol and the generally positive response of the signatories in practice. Part IV will discuss the technical aspects of nuclear weapons production and ways in which the international community can prevent conversion of peaceful nuclear technology into military use. An argument is made that nuclear nonproliferation and increased nuclear energy production are mutually compatible goals. Finally, Part V will suggest some possible solutions that would strengthen nonproliferation efforts while encouraging peaceful use of nuclear energy.

II. THE INTERNATIONAL LEGAL NORMS OF NUCLEAR ENERGY PRODUCTION

A. STATES' RIGHTS TO PEACEFUL USE OF NUCLEAR ENERGY

Until the NPT came into force in 1970, the international "right" to peaceful use of nuclear energy could be said to be derived from customary international law regarding state sovereignty over domestic economic infrastructure, resources, and activities.[17] The UN General Assembly has been particularly protective of states' rights to their domestic resources, such as uranium ores, even going so far as to approve expropriation of mining interests from foreign companies.[18] So too, the construction and operation of sedentary nuclear power plants is well within the sovereign territorial jurisdiction of individual states.[19]

For those states willing to become signatories to the NPT, a firm treaty right to the use of nuclear energy was codified in Article IV in the

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[17] This concept of sovereignty is often referred to as "internal sovereignty." BLACK'S LAW DICTIONARY 1430 (8th ed. 2004).

[18] *See, e.g.*, G.A. Res. 1803 (XVII), at 15, U.N. Doc. A/5217 (Dec. 14, 1962) ("expropriation . . . shall be based on grounds or reasons of public utility, security or the national interest"); G.A. Res. 3171 (XXVIII) at 52, UN Doc. A/RES/3175 (Dec. 17, 1973) (the General Assembly "strongly reaffirms the inalienable rights of States to permanent sovereignty over all their natural resources").

[19] Joint Report, Org. Econ. Coop. & Dev. [OECD], Nuclear Energy Agency [NEA] & Int'l Atomic Energy Agency [IAEA], *International Nuclear Law in the Post-Chernobyl Period*, at 8, NEA No. 6146 (2006), *available at* http://www.nea.fr/html/law/chernobyl/nea6146-iaea-chernobyl.pdf [hereinafter *Nuclear Law*].

form of an "inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination. . . ."[20] The consequence of gaining this "inalienable right" was the necessity of adhering to the other articles of the treaty. Of particular importance was the definition of Article IX(3), which classifies all nations that have not detonated a nuclear device by January 1, 1967, as "non-nuclear weapons states."[21] A non-nuclear weapons state could not, under any circumstance, acquire nuclear weapons, although no enforcement mechanism is in place to prevent such an occurrence, short of limiting future access to nuclear technology.[22]

Although the right to peaceful use of nuclear technology rests on firm foundations, some have argued that the right to use nuclear energy is indistinguishable from the right to possess nuclear weapons, and therefore neither should be viewed as inalienable.[23] The logic of this argument has two critical flaws. First, the use of nuclear technology for energy generation does not automatically imply an intention, or even a capability, of assembling a nuclear arsenal.[24] Second, there may exist a sovereign right to use nuclear technology not only for peaceful purposes but for defensive military purposes as well. The Bharatiya Janata Party of India, for example, has often claimed that India has a right to nuclear weapons.[25] Although not specific about the type of weaponry allowed, Article 51 of the UN Charter recognizes "an inherent right of individual or collective [member nations to] self-defense if an armed attack occurs."[26] And in 1996 the International Court of Justice, by an eleven-to-three vote, determined that "[t]here is in neither customary nor conventional international law any comprehensive and universal prohibition of the threat or use of nuclear weapons as such."[27] On the other hand, the Bush doctrine argues that a sufficiently hostile state attempting to acquire nuclear weapons could be subject to a preemptive

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[20] NPT, *supra* note 2, art. IV ¶ 1.

[21] *Id.* art. IX ¶ 3.

[22] *Id.*

[23] *See* Michael Levi, *There is No Absolute Right to Nuclear Energy*, FIN. TIMES (UK), Sep. 22, 2004, at 15.

[24] *See infra* Part IV.A.

[25] Henry Sokolski, Op-Ed., *A Blast of Reality*, N.Y. TIMES, May 13, 1998, at A23.

[26] U.N. Charter art. 51.

[27] Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, 1996 I.C.J. 226, 266 (July 8) (approved by a majority of eleven votes to three).

military strike under well-established principles of international law.[28] Although the right to possession of nuclear weapons may still be an open question, the right to peaceful use of nuclear energy must be recognized as well-established in international law.

Non-signatories to the NPT,[29] which do not benefit from a firm treaty right under Article IV, can bolster their case for nuclear energy by arguing necessity. North Korea is almost certainly sincere in wanting to use nuclear power for generation of electricity.[30] In addition, India has been forceful in asserting its right to the use of nuclear energy for the simple reason that nuclear energy has the potential of bridging the gap between its projected consumption and supply of energy.[31] The Indian Department of Atomic Energy projects that its electricity production will increase by at least a factor of ten in the next fifty years due to rapid growth in the nation's GDP.[32]

An environmental responsibility argument can also be made for the generation of nuclear energy. According to Principle 21 of the Stockholm Declaration on the Human Environment, "States have . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States."[33] In the context of reducing global warming, nuclear energy is an environmentally responsible solution in that it produces almost no greenhouse gases.[34]

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[28] THE WHITE HOUSE, THE NATIONAL SECURITY STRATEGY OF THE UNITED STATES OF AMERICA 15 (2002), *available at* http://www.whitehouse.gov/nsc/nss.pdf. For a discussion of the legality of the "Bush Doctrine" under international law s*ee* Anthony Dworkin, *Introduction*, *in* Crimes of War Project, Iraq and the "Bush Doctrine" of Pre-Emptive Self-Defence (Aug. 20, 2002), http://www.crimesofwar.org/expert/bush-intro.html.

[29] At the present time, only four major states remain non-signatories to the NPT—India, Pakistan, Israel and North Korea (which withdrew in 1994 and again in 2003). David S. Jonas, *Variations on Non-Nuclear: May the "Final Four" Join the Nuclear Nonproliferation Treaty as Non-Nuclear Weapon States While Retaining Their Nuclear Weapons?*, 2005 MICH. ST. L. REV. 417, 418 n.5.

[30] Nighttime satellite photographs of East Asia famously show the striking difference between North Korea and its well-lit neighbor to the south. *See* Astronomy Picture of the Day, Nov. 27, 2000, http://apod.gsfc.nasa.gov/apod/ap001127.html (to obtain a high resolution image, follow the "earth picture" hyperlink then follow the "image zoom icon" hyperlink).

[31] India Dep't of Atomic Energy [IDAE], A Strategy for Growth of Electrical Energy in India, DAE Doc. 10, http://www.dae.gov.in/publ/doc10/ (follow "Meeting Demand Projec." hyperlink for a discussion of the potential for nuclear power to "significantly" reduce the gap between demand and supply of electrical energy) (last visited Dec. 9, 2006).

[32] *Id.* (follow "Electricity Demand Projec." hyperlink for a discussion of the projections of demand for electrical power in India to 2052-53).

[33] United Nations Conference on the Human Environment, Stockholm, Swed., June 5-16, 1972, *Declaration of the United Nations Conference on the Human Environment*, Principle 21, U.N. Doc. A/CONF.48/14/Rev.1.

[34] *See infra* Part III.A.

The environmental argument cuts both ways, however, since a Chernobyl style nuclear accident would also have a multinational environmental impact.[35] Although the Chernobyl disaster did not result in new international law norms forbidding potentially dangerous nuclear power plants,[36] it did prompt the creation of numerous international treaties governing the safety of the nuclear power industry.[37]

From an international law perspective, the possibility of nuclear weapons proliferation does not negate the sovereign right of states to develop peaceful nuclear energy programs.[38] Nuclear proliferation is a pressing global concern, but viewing nonproliferation and the peaceful generation of nuclear energy as polar opposites requiring a delicate balancing act is shortsighted. This Comment will argue that the right to peaceful use of nuclear energy is compatible with the goal of reducing the threat of nuclear proliferation. This is particularly true in the context of regulating the nuclear fuel cycle.[39]

B. THE RIGHT TO ACCESS TO NUCLEAR MATERIALS AND TECHNOLOGY

For states that have no access to domestic supplies of uranium ores, there is no customary international law right to access nuclear fuels. Such an inherent right would place an obligation on other states to provide nuclear materials at a reasonable price whenever a resource-poor state so requests. International law does not contemplate any such obligation. On the other hand, signatories to the NPT benefit from the wording of Article IV, section 2, which states that "[a]ll parties to the Treaty undertake to facilitate . . . the fullest possible exchange of . . . materials . . . for the peaceful uses of nuclear energy."[40] Furthermore, the

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[35] Although the areas designated as "contaminated" by the Chernobyl disaster were, at the time, confined to the Soviet Union, the extent of "contaminated" areas now encompasses the modern nations of Belarus, the Russian Republic, and the Ukraine. The Chernobyl Forum, *Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine*, at 7, IAEA Doc. IAEA/PI/A.87 Rev.2/06-09181 (Apr. 2006), *available at* http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf.

[36] In fact, the last reactor at Chernobyl was not shut down until 2000. Michael Wines, *Workers Bid Ill-Fated Chernobyl a Bitter Farewell*, N.Y. TIMES, Dec. 15, 2000, at A3.

[37] *See generally Nuclear Law*, *supra* note 19.

[38] Mechanisms do exist, however, to deny nuclear technology and materials to suspect states. *See infra* Part II.B.

[39] *See infra* Part V.C.

[40] NPT, *supra* note 2, art. IV ¶ 2.

treaty contemplates that states with access to nuclear technology "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."[41]

The way states share nuclear materials and technology has evolved significantly over the years. The idea of sharing peaceful nuclear technology internationally arose originally from the Eisenhower administration.[42] On December 8, 1953, President Eisenhower delivered his famous Atoms for Peace speech to the United Nations.[43] In it, he expressed optimism that "if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, this capability would rapidly be transformed into universal, efficient and economic usage."[44] A year later, the Atomic Energy Act[45] was passed, allowing transfer of peaceful nuclear technologies to other countries. Soon after, in 1956, the International Atomic Energy Agency (IAEA) was founded to oversee the transfer of nuclear technology and to keep track of all fissionable material worldwide.[46]

Today, export of nuclear materials and technology by nuclear states is carefully controlled. Although each state determines when and how it exports nuclear technology and materials, export controls are generally based on guidelines published by the Nuclear Suppliers Group (NSG), a consortium of forty-five nuclear energy states.[47] Ironically, the NSG was founded in 1975 in direct response to the detonation of a nuclear bomb by India,[48] which is now asking to become a member.[49] As currently written, the guidelines do not require that a state receiving nuclear materials or technologies be a member of the NPT, only that the receiving state submit to IAEA safeguards "on all source and special

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41 *Id.*

42 Leonard Weiss, *Atoms for Peace*, BULL. ATOM. SCIENTISTS, Nov./Dec. 2003, at 34, 34.

43 *Id.*; Eisenhower, *supra* note 12.

44 Eisenhower, *supra* note 12, at 820.

45 42 U.S.C. §§ 2011-2059 (2004).

46 Statute of the International Atomic Energy Commission [IAEC], Oct. 26, 1956, 276 U.N.T.S. 4.

47 Nuclear Suppliers Group [NSG], Participants, http://www.nuclearsuppliersgroup.org/members.htm (last visited Oct. 15, 2006).

48 IAEA, *Communication of 10 May 2005 Received from the Government of Sweden on Behalf of the Participating Governments of the Nuclear Suppliers Group*, ¶ 11, IAEA Doc. INFCIRC/539/Rev.3 (2005). Bernard Weinraub, *Atom Test Buoys Indians' Morale*, N.Y. TIMES, May 20, 1974, at 1.

49 Fact Sheet, *supra* note 1.

fissionable material in its current and future peaceful activities."[50] For non-signatories to the NPT, none of which currently submit to full IAEA inspections, the guidelines provide an effective bar on the importation of nuclear materials and technology. However, the U.S.-India Civil Nuclear Cooperation Initiative may eventually lead to a softening of the restrictions on exports so that at least one de facto nuclear weapons state outside the NPT will be allowed to participate in the global nuclear market.[51]

Although the NPT requires signatories to share nuclear technology "without discrimination," in practice the NSG is selective about whom it shares technology and materials with.[52] However, five nuclear powers—China, India, Iran, Israel, and Pakistan—are not members of the NSG and are therefore not bound by its proscriptions.[53] The result is that any state with sufficient resources will probably be able to initiate a nuclear energy program even over the objections of the NSG.[54] Moreover, those states that do acquire nuclear programs need only point to Article IV of the NPT as their justification. Thus, in addition to being contrary to the provisions of Article IV, attempts to deny a state nuclear technology may be futile as well.[55] Some have even argued that denying a signatory state access to nuclear materials and technology may actually increase the probability of that state developing the capacity to process fuel domestically or obtaining it through black market channels.[56]

The above discussion applies to the peaceful use of nuclear energy, which according to the theme of this Comment should be the

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[50] IAEA, *Communications Received from Certain Member States Regarding Guidelines for the Export of Nuclear Material, Equipment and Technology*, ¶ 4(a), IAEA Doc. INFCIRC/254/Rev.7/Part 1 (Feb. 23, 2005) [hereinafter *Guidelines Part 1*].

[51] For example, IAEA Director General Mohamed ElBaradei hailed the U.S.-India agreement as an "important step towards satisfying India's growing need for energy." Press Release, IAEA, IAEA Director Welcomes U.S. and India Nuclear Deal (Mar. 2, 2005), http://www.iaea.org/NewsCenter/PressReleases/2006/prn200605.html.

[52] NPT, *supra* note 2, art. IV ¶ 1.

[53] Natasha Bajema & Mary Beth Nikitin, *Assessing Nuclear Maturity: Determining Which States Should Have Access to What Nuclear Technology*, FLETCHER FORUM WORLD AFF., Summer 2004, at 157, 165.

[54] China, for example, assisted North Korea in constructing its first reactor in 1986. Robert S. Norris, *North Korea's Nuclear Program*, BULL. ATOM. SCIENTISTS, Mar./Apr. 2003, at 74.

[55] Bajema & Nikitin, *supra* note 53, at 164 ("Nonproliferation policies involving technology denial have not worked well in the past and do not represent viable long-term solutions.").

[56] *See, e.g.*, Thomas L. Neff, Ctr. for Int'l Studies, Mass. Inst. Tech., The Nuclear Fuel Cycle and the Bush Nonproliferation Initiative, address at World Nuclear Fuel Cycle 2004 (Apr. 1, 2004), *available at* http://www.iaea.org/NewsCenter/Focus/FuelCycle/neff.pdf.

right of every nation. Unfortunately, nuclear weapons programs require similar technology and materials, namely, fissile material, nuclear reactors, and processing equipment.[57] A proper understanding of the technical difficulties involved in converting a peaceful nuclear program into a weapons program is necessary before evaluating the proliferation consequences of increasing worldwide nuclear energy production. Part IV.A. will discuss the technicalities involved while Part V will offer some technical and legal solutions to the problem of weapons conversion.

III. GLOBAL WARMING AND NUCLEAR ENERGY IN THE INTERNATIONAL ARENA

A. NUCLEAR ENERGY AS A SOLUTION TO GLOBAL WARMING

Global warming is an international problem. General scientific consensus is that the world's climate is warming at a rate too fast to explain by natural variations alone.[58] Scientists attribute the warming to the release of man-made greenhouse gases (GHGs) into the atmosphere over at least the last century.[59] Of greatest concern is the release of carbon dioxide into the atmosphere due to combustion of fossil fuels.[60]

The solution to stopping or even reversing global warming is to reduce the level of GHG emissions and, to a lesser extent, to provide "sinks" for existing GHGs (e.g., reforestation, which absorbs carbon dioxide).[61] One important target of GHG reduction is the electrical power generation sector. Wind, hydroelectricity, and nuclear power are the three primary emission-free technologies that are both currently available and commercially feasible.[62] Solar power, unfortunately, has

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[57] *See infra* Part IV.A.

[58] Intergovernmental Panel on Climate Change, *Climate Change 2001: Synthesis Report*, 4-8 (2001).

[59] *Id.* at 14-16.

[60] *Id.* at 19.

[61] *Id.* at 23-25.

[62] In the United States, all renewable energy sources combined provide an insignificant fraction (2.3%) of all electrical power generation compared with nuclear (19.3%) and hydroelectric (6.5%) power. U.S. DEP'T OF ENERGY [USDOE], ENERGY INFO. ADMIN., ELEC. POWER ANN. 2005, DOE/EIA-0348 (2005), *available at* http://www.eia.doe.gov/cneaf/electricity/epa/epa.pdf. However, wind power has been very successfully deployed in Europe during the last decade and

yet to entice commercial investors in the absence of huge government subsidies.[63] Of these, nuclear power provides for 75 percent of emission-free electrical power generation in the United States.[64] It also provides for 20 percent of the total U.S. electrical power capacity.[65] Worldwide, nuclear energy accounts for 17 percent of the total electrical power capacity.[66] The Nuclear Energy Agency estimates that even this modest use of nuclear energy results in a present reduction of 17 percent in GHG emissions from the electricity sector.[67] Thus, at a minimum, phasing out of nuclear power would have serious consequences for our ability to produce emission-free electrical power.

Critics of nuclear power emphasize the role of renewable technologies, particularly solar and wind power.[68] However, hydroelectric power, which provides almost a quarter of the emission-free electrical power in the United States,[69] is shunned by environmentalists for its effects on river ecosystems.[70] There are relatively few places left in the developed world in which to construct hydroelectric power plants, so the debate over the relative merits of hydroelectricity may be already passé.[71] Solar and wind power suffer from the drawback of being unable to provide continuous and predictable supplies of electricity (i.e., the wind doesn't always blow nor does the sun always shine). Unfortunately, there are no existing technologies for storing energy on large scales for use during periods of low power

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should therefore be included as a commercially feasible technology. WILLIAM SWEET, KICKING THE CARBON HABIT: GLOBAL WARMING AND THE CASE FOR RENEWABLE AND NUCLEAR ENERGY 152-55 (2006).

63 SWEET, *supra* note 62, at 155-58.

64 Timothy Walsh, Note, *Turning Our Backs: Kyoto's Mistaken Nuclear Exclusion*, 16 GEO. INT'L ENVTL. L. REV. 147, 156 (2003).

65 *Id.* at 155-156; Beller, *supra* note 16, at 41.

66 Beller, *supra* note 16, at 47.

67 OECD, NEA, *Nuclear Energy and the Kyoto Protocol*, at 7, NEA No. 3808 (2002) [hereinafter NEA Kyoto Report], *available at* http://www.nea.fr/html/ndd/reports/2002/nea3808-kyoto.pdf.

68 *See, e.g.*, SIERRA CLUB, 2006 ENERGY RESOURCES POLICY 8-10, *available at* http://www.sierraclub.org/policy/conservation/energy.pdf.

69 Beller, *supra* note 16, at 46.

70 The Sierra Club routinely opposes construction of new hydroelectric power plants. *See* Sierra Club, Renewable Energy Technologies and Their Pros and Cons, http://lomaprieta.sierraclub.org/greenpower/renewabletech.htm (last visited Feb. 20, 2007) ("It is unfortunate that 24 percent of current U.S. energy supply comes from large hydropower, considering its environmental effects.").

71 Hydroelectric power production is unlikely to increase significantly in the future due to the fact that there are very few suitable locations left to exploit. USDOE, ENERGY INFO. ADMIN., RENEWABLE RESOURCES IN THE U.S. ELECTRICITY SUPPLY, at x, DOE/EIA-0561(92) (1993), *available at* ftp://ftp.eia.doe.gov/pub/electricity/renewmas.pdf.

output.[72] In addition, solar and wind power plants require enormous footprints compared to more traditional power sources. For example, a typical one thousand megawatt nuclear plant occupies less than ten acres of land while a one thousand megawatt wind plant would occupy two hundred fifty square miles.[73] As the residents of Cape Cod recently discovered when confronted with the specter of a wind farm intruding on their beautiful ocean view, renewable energy is not the panacea that environmentalists had predicted.[74] Even so, Europeans have obtained significant supplemental wind power over the last decade,[75] and the United States should consider doing the same.

A second line of thought among environmentalists argues that an increase in efficiency would allow a reduction in fossil fuel energy production.[76] Efficiency arguments fail to take into account an important reality: the exponential growth of electrical power consumption. World energy consumption is increasing at a rate of about 2 percent per year, with a doubling time of about thirty-five years.[77] Even a spectacularly successful worldwide increase in efficiency of 50 percent today would require the same amount of energy generation in 2041 as we currently have in 2006. In addition, historical evidence shows that increased efficiency does not lead to reduced energy consumption.[78] By way of illustration, steadily increasing automobile efficiency has not led to significant reduction in mileage because consumers tend to pour their savings into bigger, more powerful, and more luxurious automobiles.[79] Finally, almost a third of the human population lacks adequate electricity, mostly among populations living in underdeveloped countries.[80] Inequitable distribution of electrical energy among rich and

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[72] Although one suggested solution is to use electricity to separate hydrogen from water, which can then be liquefied and stored as an energy source. *See* JEREMY RIFKIN, THE HYDROGEN ECONOMY 186 (2003).

[73] Walsh, *supra* note 64, at 167.

[74] A company called Cape Wind is planning to build a wind powered electrical plant just off the coast of Nantucket Sound. For a small sample of the contentious battle raging between the traditionally liberal residents and Cape Wind, *see* Cornelia Dean, *A Seashore Fight to Harness the Wind*, N.Y. TIMES, Nov. 14, 2004, at A22.

[75] SWEET, *supra* note 62, at 152-55.

[76] *See, e.g.*, Amory B. Lovins, *More Profit with Less Carbon*, SCI. AM., Sept. 2005, at 74.

[77] USDOE, ENERGY INFO. ADMIN., INT'L ENERGY ANNUAL 2004 (2006), at 7, *available at* http://www.eia.doe.gov/iea/overview.html.

[78] VACLAV SMIL, ENERGY AT THE CROSSROADS: GLOBAL PERSPECTIVES AND UNCERTAINTIES 335 (2003).

[79] SWEET, *supra* note 62, at 164-65.

[80] *See* Beller, *supra* note 16, at 42-43.

poor nations mirrors the economic inequalities among nations, resulting in "energy apartheid."[81] Any solution to this energy apartheid problem necessarily involves increasing energy production in impoverished countries.[82] Thus one expects exponential growth of energy consumption to continue well into the foreseeable future. Energy efficiency, although a worthy goal, is a temporary solution at best.

India's projected energy needs illustrate the magnitude of the problem. Although the population is projected to grow by only about 32 percent between 2005 and 2025,[83] energy consumption is expected to more than double in that same period.[84] The growth of India's energy consumption far outpaces its population growth because its gross domestic product is growing at a far faster rate.[85] India needs energy not because it is growing significantly in population, but because it wishes to join the community of developed nations. Since one cannot expect India to abandon that worthy goal, the best one can hope for is that India will provide for its enormous energy needs in an environmentally responsible way. Toward that end, India's Department of Atomic Energy has determined that nuclear energy is necessary for meeting its long term energy requirements.[86]

Opponents of nuclear energy argue that nuclear power is unsafe and environmentally unfriendly.[87] These two arguments deserve a treatise of their own but can be addressed briefly with the following testable assertion: nuclear power is safe and nuclear power is clean.[88]

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[81] *Id.* at 43.

[82] Energy commentators often forget that people in developing countries want and deserve the amenities of the developed world. *See, e.g.*, Daniel M. Kammen, *The Rise of Renewable Energy*, SCI. AM., Sept. 2006, at 84, 86 (noting with admiration that Kenya has more solar power systems installed per capita than any nation on earth, despite the fact that the systems provide only a few hours of electricity per day).

[83] U.S. Census Bureau, Int'l Database, Summary Demographic Data for India, http://www.census.gov/ipc/www/idbsum.html (select "India" from the list menu) (data updated Aug. 24, 2006) (last visited Dec. 9, 2006) [hereinafter India Census Data].

[84] USDOE, ENERGY INFO. ADMIN., INTERNATIONAL ENERGY OUTLOOK 2006, at 146, *available at* http://www.eia.doe.gov/oiaf/ieo/index.html (last visited Feb. 20, 2007).

[85] For example, India's average annual population growth rate between 2000 and 2010 is estimated at 1.6 percent per year. India Census Data, *supra* note 83. On the other hand, India's gross domestic product has increased or is projected to increase between 6.7 and 6.9 percent per year between 2004 and 2006. USDOE, ENERGY INFO. ADMIN., COUNTRY ANALYSIS BRIEFS, INDIA 1 (2005), *available at* http://www.eia.doe.gov/emeu/cabs/India/pdf.pdf.

[86] INDIA DEP'T ATOMIC ENERGY, LONG TERM VISION OF THE DEPARTMENT OF ATOMIC ENERGY 1, *available at* http://www.dae.gov.in/publ/vision.pdf (last visited Feb. 20, 2007).

[87] *See supra* note 14 and accompanying text.

[88] Press Release, Global Nuclear Energy P'ship [GNEP], Department of Energy Announces New Nuclear Initiative (Feb. 6, 2006), *available at* http://www.gnep.energy.gov/gnepPRs/

Even including the Chernobyl disaster, nuclear power has resulted in significantly fewer deaths per billion watts of energy than hydroelectric, coal, and natural gas power plants.[89] Risk assessment analysis confirms this conclusion.[90] As for environmental impact, nuclear power produces a negligible amount of environmental emissions relative to fossil fuels.[91] The volume of waste is also orders of magnitude smaller than the waste due to fossil fuels and is entirely in solid form, which can be easily segregated from the environment.[92] In fact, the entire volume of nuclear waste generated up to the year 2004 in the United States would only fill a football field five yards deep.[93]

It seems, then, that nuclear energy fills an urgent need for emission-free energy in an era of serious concern about global warming. Paradoxically, the global community has responded less than enthusiastically so far.[94] However, attitudes in the international arena are beginning to change.

On February 6, 2006, the United States announced its intention to expand the use of nuclear energy worldwide with the creation of the Global Nuclear Energy Partnership (GNEP).[95] The effort is part of the Advanced Energy Initiative announced by President Bush during the 2006 State of the Union Address.[96] The articulated goals of GNEP emphasize reducing dependence on foreign energy sources, economic growth, non-proliferation, and environmental goals such as clean

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gnepPR020606.html ("Nuclear energy is safe, environmentally clean, reliable, and affordable"). *See also* Beller, *supra* note 16, at 48-52.

89 By way of illustration, over one hundred thousand coal miners have been killed in the United States since 1900. U.S. Dep't of Labor, Mine Safety and Health Admin., Coal Fatalities for 1900 through 2005, http://www.msha.gov/stats/centurystats/coalstats.htm (last visited Dec. 9, 2006). By comparison, the Chernobyl disaster resulted in 31 direct fatalities and an estimated 4,000 indirect deaths due to radiation induced cancers. The Chernobyl Forum, *supra* note 35, at 14-16.

90 For a calculation of fatalities per billion watts of energy per year for various energy sources, *see* Paul Scherrer Institut, Risk Assessment, Selected Results, http://gabe.web.psi.ch/research/ra/ra_res.html (last visited Dec. 9, 2006).

91 *See* USDOE, ENERGY INFO. ADMIN., NUCLEAR POWER AND THE ENVIRONMENT, http://www.eia.doe.gov/cneaf/nuclear/page/nuclearenvissues.html (last visited Dec. 9, 2006).

92 *Id.*

93 USDOE, OFF. CIVILIAN RADIOACTIVE WASTE MGMT., FACT SHEET: WHAT ARE SPENT NUCLEAR FUEL AND HIGH LEVEL RADIOACTIVE WASTE?, DOE Doc. DOE/YMP-0338 (Sept. 2004), http://www.ocrwm.doe.gov/factsheets/doeymp0338.shtml (last visited Feb. 20, 2007).

94 Austria, for example, has abandoned nuclear power. SWEET, *supra* note 62, at 183.

95 Press Release, GNEP, *supra* note 88.

96 President George W. Bush, Address Before a Joint Session of the Congress on the State of the Union, 42 WEEKLY COMP. PRES. DOC. 145, 150 (Jan. 31, 2006).

development and reduction of nuclear waste.[97] Mitigation of the global warming problem is not specifically mentioned, perhaps as a political concession to a subsection of the president's base that is skeptical of global warming.[98] The GNEP does, however, appear to be committed to expanding the use of nuclear energy worldwide, which would certainly go a long way towards reducing the emission of GHGs.[99] It proposes to achieve this goal by reviving processing of spent nuclear waste in the United States and creating a "fuel service program that would allow developing nations to acquire and use nuclear energy economically while minimizing the risk of nuclear proliferation."[100] Implicit in this statement is the belief that nuclear energy has a net global benefit and that the goals of reducing both global warming and nuclear proliferation are mutually compatible. Reforms to the global nuclear fuel cycle as a solution to both problems are discussed *infra* in Parts IV.B. and V.C.

B. THE INTERNATIONAL RESPONSE TO GLOBAL WARMING AND NUCLEAR ENERGY

Several international efforts have been made to address the global warming problem. The United Nations Framework Convention on Climate Change entered into force in 1994 in an attempt to bring the global GHG levels back to their 1990 levels.[101] Unfortunately, the Framework Convention did not set a timetable, nor did it provide legally binding methods of implementing the goal of the treaty.[102] To address

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[97] Press Release, GNEP, *supra* note 88 ("The Global Nuclear Energy Partnership has four main goals. First, reduce America's dependence on foreign sources of fossil fuels and encourage economic growth. Second, recycle nuclear fuel using new proliferation-resistant technologies to recover more energy and reduce waste. Third, encourage prosperity growth and clean development around the world. And fourth, utilize the latest technologies to reduce the risk of nuclear proliferation worldwide.").

[98] Nuclear energy was mentioned briefly as a possible solution to "global climate change" in a speech from June of 2001. Remarks on Global Climate Change, 1 PUB. PAPERS 634, 637 (June 11, 2001). In a climate change fact sheet released in May of 2005, nuclear energy is mentioned only once in the context of the Generation IV International Forum. Press Release, The White House, Climate Change Fact Sheet: The Bush Administration's Actions on Global Climate Change (May 18, 2005), http://www.whitehouse.gov/news/releases/2005/05/20050518-4.html.

[99] GNEP, Press Release, *supra* note 88.

[100] *Id.*

[101] United Nations Framework Convention on Climate Change art. 2, May 9, 1992, 31 I.L.M. 849, 854, 1771 U.N.T.S. 107, 169; Walsh, *supra* note 64, at 150.

[102] Walsh, *supra* note 64, at 150.

these problems, the Kyoto Protocol to the United Nations Framework Convention on Climate Change was approved in 1997.[103]

The Kyoto Protocol provided three mechanisms for implementing the goal of reducing GHGs to their 1990 levels. The first was Joint Implementation, which allowed Annex I countries (mostly developed nations) to get credit for joint ventures that reduced GHG emissions.[104] Second was the Clean Development Mechanism, which allowed developed countries to receive credit for reducing GHGs in the developing world.[105] Third was Emission Trading, which provided a mechanism for efficient distribution of the costs of GHG reduction among nations.[106]

Surprisingly, nuclear energy is never mentioned in either the Framework Convention or the Kyoto Protocol. In fact, at the Sixth Meeting of the Conference of Parties in 2001, signatories to the Kyoto Protocol announced that nuclear power would not be given credit under either the Joint Implementation or the Clean Development Mechanism.[107] Specifically, Annex I countries are to "refrain from using emission reduction units generated from nuclear facilities to meet their commitments under Article 3.1 [of the Kyoto Protocol]."[108] The rationale appears to be that these two mechanisms should emphasize only renewable energy resources, such as wind, solar, and hydroelectricity. Thus it seems that the international community means to take nuclear energy out of consideration as a possible solution to the global warming problem. On the other hand, treaty members reserve the "prerogative to confirm whether a clean development mechanism project activity assists it in achieving sustainable development."[109] Understandably, the Nuclear Energy Agency is not particularly sanguine about the possibility of member states asserting that nuclear energy is a sustainable resource.[110]

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[103] U.N. Framework Convention on Climate Change [UNFCCC], *Kyoto Protocol to the United Nations Framework Convention on Climate Change*, Dec. 10, 1997 [hereinafter *Kyoto Protocol*], *in Report of the Conference of the Parties on its Third Session, Held at Kyoto From 1 to 11 December 1997*, at 8, UN Doc. FCCC/CP/1997/7/Add.1 (Mar. 25, 1998).

[104] *Id.* art. 6.

[105] *Id.* art. 12.

[106] *Id.* art.17.

[107] UNFCCC, *Report on the Conference of the Parties on the Second Part of its Sixth Session, Held at Bonn From 16 to 27 July 2001*, at 43, U.N. Doc FCCC/CP/2001/5 (Sept. 24, 2001).

[108] *Id.* at 43.

[109] *Id.*

[110] NEA Kyoto Report, *supra* note 67, at 31.

In practice, signatories to the Kyoto Protocol have been less than enthusiastic about letting their nuclear programs lapse given their GHG reduction obligations under the treaty.[111] China currently has aggressive plans to expand its nuclear energy sector.[112] India, Pakistan, Iran, Vietnam, North Korea, South Korea and Japan are all expanding their nuclear programs.[113] Brazil and Argentina have followed suit.[114] In Europe, which suffered most from the environmental backlash against nuclear power after Chernobyl, only Germany and Belgium are attempting to phase out their nuclear programs.[115] France, Romania, Finland, and the Czech Republic are actively attempting to increase their nuclear output.[116] In fact, the European Commission (EC) grudgingly admits in its Green Paper *Towards a European Strategy for the Security of Energy Supply* that "the absence of nuclear [energy] would make it even more difficult to tackle climate change in the long term."[117] However, the EC was reluctant to fully endorse nuclear energy as a solution to global warming except as an apparent afterthought:

> The future of nuclear energy in Europe is uncertain, particularly in Europe. It depends on several factors, including: a solution to the problems of managing and stocking nuclear waste, the economic viability of the new generation of power stations, the safety of reactors in Eastern Europe, in particular applicant countries, and the fight against nuclear proliferation in the CIS. Policies to combat global warming should also play a fundamental role.[118]

This statement outlines four concerns of the EC regarding nuclear energy. There is the perennial concern about nuclear waste[119] but no mention of toxic emissions due to existing reactors. The economic viability argument may be of less concern given the expense of

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[111] Beller, *supra* note 16, at 52-55.

[112] *See* Ling Zhong, Note, *Nuclear Energy: China's Approach Towards Addressing Global Warming*, 12 GEO. INT'L ENVTL. L. REV. 493, 495 (2000).

[113] Beller, *supra* note 16, at 52.

[114] *Id.* at 53.

[115] Peter Ford, *Europe Warms to Nuclear Power*, CHRISTIAN SCI. MONITOR, Jan. 6, 2006, at 6. Belgium may reconsider its phase out in light of a pro-nuclear report by the Federal Planning Bureau. *Id.* Even Germany may reconsider if newly-elected Chancellor Angela Merkel can overcome opposition by members of her fractious coalition. *Id.*

[116] Beller, *supra* note 16, at 53.

[117] *Commission Green Paper, Towards a European Strategy for the Security of Energy Supply*, at 81, COM (2000) 769 final (adopted by the European Commission on November 29, 2000), *available at* http://ec.europa.eu/energy/green-paper-energy-supply/doc/green_paper_energy_supply_en.pdf.

[118] *Id.* at 33.

[119] *See supra* Part III.A.

implementing the Kyoto Protocol, particularly if nuclear energy is allowed to receive credit under the Joint Implementation and Clean Development Mechanism.[120] Interestingly, the concern over safety in Eastern Europe implies a confidence in the safety of Western reactors. That leaves only the non-proliferation argument, which is the subject of Part IV of this comment.

IV. NUCLEAR NON-PROLIFERATION CONCERNS RELATING TO NUCLEAR ENERGY PROGRAMS

A. THE TECHNICAL ASPECTS OF NUCLEAR WEAPONS PRODUCTION

Most commentators agree that the limiting factor in acquiring a nuclear weapon is the availability of weapons-grade nuclear material.[121] Once the nuclear material is obtained, actual design and construction of the weapon can proceed using publicly available information and access to conventional materials.[122] Only two isotopes are thought to be suitable for constructing a nuclear weapon—uranium-235 and plutonium-239.[123] Naturally occurring uranium, which consists primarily of the isotope uranium-238, contains only 0.072 percent of the fissile isotope uranium-235.[124] Thus, naturally occurring uranium must be "enriched" to increase the uranium-235 content—an extremely technically challenging process because the two isotopes are almost chemically identical.[125]

Plutonium-239 does not normally occur in nature and must be generated from transmutation of uranium-238 in a nuclear reactor.[126] Consequently, all reactors, including power plant designs, generate some plutonium-239 because of the presence of uranium-238 in the reactor

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[120] NEA Kyoto Report, *supra* note 67, at 41.

[121] *See, e.g.*, Robert Chesney, *National Insecurity: Nuclear Material Availability and the Threat of Nuclear Terrorism*, 20 LOY. L.A. INT'L & COMP. L.J. 29, 36-38 (1997).

[122] In 1964 the U.S. government conducted a test called the "Nth Country Experiment." Dan Stober, *No Experience Necessary*, 59 BULL. ATOM. SCIENTISTS, Mar./Apr. 2003, at 56, 58. A group of young physicists, none of whom had experience with nuclear physics, were asked to design a nuclear weapon from publicly available information. *Id.* Later analysis determined that the bomb they designed was fully functional. *Id.* at 61.

[123] Chesney, *supra* note 121, at 39.

[124] *Id.* at 40.

[125] *Id.*

[126] U.S. EPA, Radiation Information: Plutonium, http://www.epa.gov/radiation/radionuclides/plutonium.htm (last visited Feb. 20, 2007).

fuel.[127] Purification of the plutonium is a much simpler process than the enrichment of uranium due to the fact that plutonium and uranium have different chemical properties.[128] Nuclear reactors called "breeder reactors" can be constructed to enhance the production of plutonium.[129] It must be noted, however, that traditional commercial nuclear reactors produce substantial quantities of undesirable isotopes of plutonium that would make the material less useful in constructing a nuclear weapon.[130] A state intent on developing a plutonium bomb would therefore have to construct a clandestine reactor designed specifically for the production of weapons-grade plutonium.[131]

One of the technical challenges to preventing proliferation through this route is to design "proliferation resistant" reactors.[132] These reactors would be designed for use with nuclear fuels containing impurities, such as undesirable isotopes, that would make it more difficult to manufacture weapons-grade material from them.[133] Such efforts will probably never be entirely fool-proof,[134] which is why the IAEA and the international community are so insistent on maintaining a schedule of regular inspections for NPT signatories. The net effect of the IAEA inspection regime is to increase the cost of developing a nuclear weapons program.[135]

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[127] Nuclear fuel for use in power plants is usually enriched to 2 to 3 percent uranium-235—most of the remainder being uranium-238. U.S. EPA, Radiation Information: Uranium, http://www.epa.gov/radiation/radionuclides/uranium.htm (last visited Feb. 20, 2007).

[128] Chesney, *supra* note 121, at 41.

[129] J. S. LILLEY, NUCLEAR PHYSICS: PRINCIPLES AND APPLICATIONS 292-93 (2001).

[130] Unfortunately, even reactor-grade plutonium can be made into nuclear weapons. J. Carson Mark, et al., *Appendix 1: Can Terrorists Build Nuclear Weapons?*, *in* NUCLEAR POWER AND THE SPREAD OF NUCLEAR WEAPONS: CAN WE HAVE ONE WITHOUT THE OTHER? 235, 238 (Paul L. Leventhal et al. eds., 2002). For a detailed description of the explosive properties of plutonium *see* J. Carson Mark, *Appendix 3: Reactor Grade Plutonium's Explosive Properties*, *in* Paul L. Leventhal et al. eds., *supra* at 261-72.

[131] OECD NEA, *Nuclear Energy in a Sustainable Development Perspective*, at 46 (2000), *available at* http://www.nea.fr/html/ndd/docs/2000/nddsustdev.pdf (last visited Dec. 14, 2006).

[132] *See, e.g.*, Seth Grae, *The Nuclear Non-Proliferation Treaty's Obligation to Transfer Peaceful Nuclear Energy Technology: One Proposal of a Technology*, 19 FORDHAM INT'L L. J. 1985, 1996-97 (1996).

[133] Center for Arms Control and Non-Proliferation, The Limited Proliferation-Resistance Benefits of the Nuclear Fuel Cycles Being Researched by the Department of Energy's Advanced Fuel Cycle Initiative, June 8, 2005, http://www.armscontrolcenter.org/archives/001711.php.

[134] *See supra* note 131. It may be that the problems associated with less-than-ideal nuclear materials can be overcome by properly engineering the bomb itself. Edwin S. Lyman, *The Limits of Technical Fixes*, *in* Paul L. Leventhal, et al. eds., *supra* note 130, at 167, 176.

[135] Amir Azaran, *NPT Where Art Thou? The Nonproliferation Treaty and Bargaining: Iran as a Case Study*, 6 CHI. J. INT'L L. 415, 416 (2005).

Both the plutonium and uranium routes to nuclear weapons development involve significant capital and technical costs: uranium weapons require a large, expensive isotope separation plant while plutonium weapons require an existing nuclear reactor.[136] Once weapons-grade material becomes available, the actual construction of the weapon is relatively straightforward, requiring nothing more than an advanced degree in engineering or physics and access to high explosives.[137] A uranium bomb using the gun-barrel design of "Little Boy" is simplest of all—in fact, the Los Alamos scientists were so certain this design would work they never bothered to test it before the bombing of Hiroshima.[138] A "Fat Man" implosive design using plutonium requires precision shaping of a high explosive charge but is not beyond the technical ability of a state-sponsored program or possibly even a well-funded NGO, such as a terrorist group.[139] In short, denying nuclear weapons to NGOs primarily involves limiting their access to weapons-grade materials. For this reason, the IAEA maintains an account of the worldwide supply of nuclear materials. Since many states are capable of initiating their own domestic fuel processing programs,[140] simply denying them access to fissile material is pointless at best and counterproductive at worst.[141]

Nevertheless, states do attempt to regulate the export of nuclear technologies by following the guidelines published by the NSG.[142] A central tenet of these guidelines is the "non-proliferation principle" whereby suppliers are cautioned to authorize transfers only when satisfied that the transfers will not contribute to the construction or use of nuclear weapons.[143] The original guidelines, now referred to as "Part 1", attempted to control the transfer of items that had obvious applications in the field of nuclear technology.[144] These are the so-called "trigger list"

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[136] Chesney, *supra* note 121, at 40-41.

[137] *See* Stober, *supra* note 122.

[138] JONATHAN MEDALIA, NUCLEAR TERRORISM: A BRIEF REVIEW OF THREATS AND RESPONSES 2 (Cong. Research Serv., CRS Report for Congress Order Code RL32595, Sept. 22, 2004), *available at* http://www.fas.org/sgp/crs/terror/RL32595.pdf.

[139] There is some disagreement as to whether a terrorist organization would be capable of constructing a plutonium weapon. *Id.* Note, however, that the test subjects of the "Nth Country Experiment" opted for the more complicated "Fat Man" design. Stober, *supra* note 122, at 59.

[140] In fact, nothing in the NPT prohibits states from developing domestic fuel processing facilities. Azaran, *supra* note 135, at 420.

[141] *See* Neff, *supra* note 56.

[142] *See supra* Part II.B.

[143] *Guidelines Part 1*, *supra* note 50, ¶ 10.

[144] *Id.*

items, such as fissile material, nuclear reactors, and processing plants.[145] After the first Gulf War, when Iraq was found to have made significant progress in its nuclear weapons program, Part 2 of the guidelines[146] was promulgated to control access to "dual-use" technologies, i.e., technologies that have both nuclear and industrial applications.[147] Before the first Gulf War, Iraq had acquired dual-use items with the intent of constructing its own items from the trigger list.[148] However, if the trigger list items can be constructed, as Iraq believed, then so can the dual-use items. The guidelines therefore have the effect of merely slowing the progress of nuclear weapons programs and making them less economically attractive.

B. PREVENTING PROLIFERATION THROUGH THE NUCLEAR FUEL CYCLE

Depleted fuel rods from nuclear power plants contain unfissionable uranium-238, fissionable uranium-235 and plutonium-239, and the waste products of the fission process, typically medium-mass isotopes, many of which are highly radioactive.[149] The nuclear fuel cycle is the process whereby used nuclear fuel is reprocessed to extract residual uranium-235, plutonium-239, or both.[150] New fuel rods are thus constructed from the reprocessed materials in the old rods, which increases the total amount of energy that can be extracted from a given amount of nuclear fuel and simultaneously reduces the amount of nuclear waste.[151] From an energy efficiency and environmental perspective, reprocessing has undeniable merits.

In 1977 President Jimmy Carter banned the reprocessing of civilian nuclear fuel rods in the United States.[152] His principal objection to reprocessing was that, at the time, reprocessing involved extraction of

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[145] *Id.* Annex A.

[146] IAEA, *Communications Received from Certain Member States Regarding Guidelines for Transfers of Nuclear-related Dual-use Equipment, Materials, Software and Related Technology*, IAEA Doc. INFCIRC/254/Rev.7/Part 2 (Mar. 20, 2006) [hereinafter *Guidelines Part 2*].

[147] IAEA, *supra* note 38, ¶¶ 14, 15.

[148] *Id.* ¶ 15.

[149] World Nuclear Assoc., Information and Issues Briefs: The Nuclear Fuel Cycle, Aug. 2005, http://www.world-nuclear.org/info/inf03.htm (last visited Feb. 20, 2007).

[150] *Id.*

[151] *Id.*

[152] President Jimmy Carter, Presidential Directive on Nuclear Non-Proliferation Policy, PD-8 (Mar. 24, 1977), *available at* http://www.fas.org/irp/offdocs/pd/index.html (originally classified Secret, this Presidential Directive has since been declassified).

pure plutonium at some point in the cycle, which led to fears of possible theft of fissile materials for manufacturing nuclear bombs.[153] In 1977 nuclear reprocessing involved the PUREX (plutonium uranium extraction) method, whereby plutonium and uranium were chemically separated and purified.[154] Since then, other more proliferation-resistant methods have been developed whereby the intermediate products of the reprocessing are unsuitable for constructing nuclear weapons without further processing, thus leaving rogue states and terrorist NGOs without easy access to weapons-grade materials.[155] Recently the GNEP expressed a preference for the UREX+ (uranium extraction plus) reprocessing method, which would keep uranium and plutonium together in the fuel cycle and avoid separating out pure plutonium.[156] This new initiative effectively ends an almost thirty-year moratorium on reprocessing in the United States.

Scientists are developing other reprocessing techniques as well. One such promising technology is pyrometallurgic processing whereby a maximum amount of energy is extracted from uranium ore while producing very little waste and no intermediate or end stage materials suitable for construction of nuclear weapons.[157] Revamping the nuclear fuel cycle in a maximally efficient and proliferation-resistant way would also involve constructing a new generation of nuclear reactors.[158] In the United States, the Department of Energy 2006 appropriation for research into advanced reactor designs that would simultaneously address economic, environmental, and nonproliferation concerns was $54.5 million.[159]

The above discussion shows that it may be technologically feasible to improve the energy efficiency of nuclear power while at the same time minimizing the potential for diverting material into nuclear weapons programs. Thus the twin goals of mitigating global warming and preventing nuclear proliferation are shown to be compatible rather

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[153] *Id.*

[154] William H. Hannum, et al., *Smarter Use of Nuclear Waste*, SCI. AM., Dec. 2005, at 84, 88.

[155] *Id.* at 88-91.

[156] USDOE, Global Nuclear Energy P'ship [GNEP], Integrated Spent Fuel Recycling Capability, http://www.gnep.energy.gov/gnepProliferationResistantRecycling.html (last visited Dec. 14, 2006).

[157] Hannum et al., *supra* note 154, at 89.

[158] *Id.*

[159] USDOE, Office of Nuclear Energy, Science and Tech., Generation IV Nuclear Energy Systems Initiative, Jan. 2006, http://nuclear.energy.gov/pdfFiles/GENIV.pdf (the FY 2007 requested appropriation is $31.4 million).

than divergent. In addition, Part V.C. will demonstrate that implementation of a multinational fuel cycle could further reduce the potential for military diversion of nuclear material.

C. PREVENTING THE CONVERSION OF PEACEFUL NUCLEAR TECHNOLOGY INTO MILITARY USE

The decision by a state to develop nuclear weapons involves a complex calculus concerning issues of security, self-perception, and economic cost. The current nonproliferation regime is designed to affect the relative weight of all three elements in order to tip the scale towards a rejection of nuclear weapons. The NPT enhances state security by limiting the number of nuclear weapons states,[160] providing for transparency in nuclear energy programs through inspection,[161] and requiring nuclear weapons states to gradually disarm.[162] Compliance with the NPT also furnishes states with a real self-perception of responsible statehood.[163] Finally, IAEA inspections and export controls implemented by the NSG are designed to increase the economic cost of developing a nuclear weapons program.[164]

A natural question to ask is how the presence of a peaceful nuclear energy program changes the factors involved in deciding whether or not to seek nuclear weapons. First, the presence of a nuclear energy program may negatively affect the sense of security felt by neighboring states if they believe it is a front for a clandestine weapons program. However, a strict IAEA inspection regime can help to mitigate such concerns. It should also be noted that building additional nuclear power plants in states with existing nuclear energy programs will not significantly affect the security interests of other non-nuclear states.[165]

Second, the presence of a domestic nuclear energy program may actually enhance a state's self-perception as "developed" and increase its desire to behave as a responsible state, e.g., to comply with the NPT. It has been suggested that in every case, states that *did* develop nuclear weapons acquired nuclear technology *for the express purpose of*

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[160] NPT, *supra* note 2, art.II.

[161] *Id.* art.III.

[162] *Id.* art.VI.

[163] Jonas, *supra* note 29, at 435.

[164] Azaran, *supra* note 135, at 416-17.

[165] *See, e.g.*, SWEET, *supra* note 62, at 193-194 (If the United States decided to boost its reliance on nuclear power it would not change the security decisions of other countries).

developing those weapons.[166] A few, like Argentina, Brazil, and South Africa, gave up their nuclear weapons ambitions with the implementation of the NPT.[167] Still others, most of Europe for example, have opted for purely civilian nuclear programs.[168] Although it is difficult to find direct evidence of motive in the secretive world of nuclear weapons programs, the historical record shows very little evidence of peaceful nuclear energy programs resulting in later decisions to pursue nuclear weapons.[169]

The final factor affecting the probability of converting nuclear energy programs into nuclear weapons programs is the economic cost involved. The IAEA inspection regime requires determined pre-nuclear weapons states to operate expensive clandestine reactors and processing facilities.[170] In addition, the NSG export controls force such states to seek technology and materials from non-NSG members or the black market, thus increasing the cost of the program.[171] As mentioned in Part IV.A., the essential elements of a nuclear weapons program—namely, fissile material, a nuclear reactor, and a processing plant—are the same elements found in full-fledged peaceful nuclear energy programs. Thus it would seem that conversion of a nuclear energy program into a weapons program should involve significantly less cost. However, nations subject to the NPT will almost certainly have to construct a secret and largely redundant nuclear program entailing very little cost savings. Diverting peaceful technology directly to military use would almost certainly result in discovery through regular IAEA inspections.

In general, the factors that determine whether an NPT signatory will pursue nuclear weapons weigh about the same whether or not that state has an existing nuclear energy program. Expanding the global use of nuclear energy should therefore have little or no effect on the prevalence of nascent nuclear weapons states. However, this conclusion assumes that states will not simply acquire nuclear technology and then abandon the NPT, as North Korea has done. As North Korea is beginning to discover, withdrawal from the NPT carries with it a unique

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[166] *Id.* at 193.

[167] SARAH J. DIEHL & JAMES CLAY MOLTZ, NUCLEAR WEAPONS AND NONPROLIFERATION: A REFERENCE HANDBOOK 20 (2002).

[168] Only France, Great Britain and the former Soviet Union opted to acquire nuclear weapons.

[169] SWEET, *supra* note 62, at 193.

[170] Iran, for example, is believed to have constructed a secret enrichment plant at Natanz. David Albright, *When Could Iran Get the Bomb?*, BULL. ATOM. SCIENTISTS, July/Aug. 2006, at 28-29.

[171] *See supra* Part II.B.

set of negative consequences and costs that are beyond the scope of this Comment.[172]

V. A NUCLEAR SOLUTION TO BOTH GLOBAL WARMING AND NONPROLIFERATION

A. CONTINUE TO RECOGNIZE THE INHERENT RIGHT TO PEACEFUL NUCLEAR TECHNOLOGY

Every nation has a right to use nuclear technology to develop emission-free energy resources, if not under Article IV of the NPT then under internationally recognized principles of state sovereignty.[173] Even though this is a tough pill for the United States to swallow in negotiating with difficult nations such as Iran and North Korea, the diplomatic emphasis must be on the nuclear weapons programs, not on the nuclear energy programs.

The right to the use of nuclear energy is only an abstraction, of course, without the necessary materials and technology to construct a working reactor. Although access to nuclear materials and technology is not a right as such, attempts by nuclear states to deny other states access to nuclear energy should be carefully considered in light of both global warming and nonproliferation policy concerns. For states such as India, which takes its nonproliferation obligations very seriously, the benefits of its use of nuclear energy are potentially enormous in light of the significant amount of GHGs that would otherwise be produced.[174] From a global warming perspective, the benefits of the U.S.-India Civil Nuclear Cooperation Initiative far outweigh any possible weakening of the NPT.

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[172] For a timeline of North Korea's ongoing confrontation with the international community, *see* Eric Yong-Joong Lee, *The Six-Party Talks and North Korean Nuclear Dispute Resolution Under the IAEA Safeguard Regime*, 5 ASIAN-PACIFIC L. & POL'Y J. 101, 116 (2004), *available at* http://www.hawaii.edu/aplpj/pdfs/v5-03-Lee.pdf.

[173] *See supra* Part II.A.

[174] Energy consumption in India is expected to double between 2002 and 2025. USDOE, INT'L ENERGY OUTLOOK 2005, http://www.eia.doe.gov/oiaf/archive/ieo05/pdf/ieosectab_10.pdf (last visited Dec. 18, 2006).

B. ACCEPT THE "GRAND BARGAIN" IN GOOD FAITH

The NPT has been effective in preventing all but two signatories (Iran and North Korea) from developing or attempting to develop nuclear weapons.[175] One nation—South Africa—was persuaded to abandon its nuclear weapons program.[176] Three other nations—Israel, Pakistan, and India—proceeded to develop nuclear weapons programs while simultaneously refusing to join the treaty.[177] Although it is virtually impossible to analyze alternative histories, an argument could be made that the NPT reduced the pressure to become a member of the "nuclear club," thereby removing any incentive for states to develop costly nuclear weapons programs of limited utility.

The "grand bargain" of the NPT is that nuclear weapons states will promise to disarm and share peaceful nuclear technology if the non-nuclear weapons states agree to forgo nuclear weapons.[178] Unfortunately, the grand bargain of the NPT contains a structural flaw that allows signatory states to cheat the system.[179] The treaty appears to reach a point of critical uselessness once two conditions are met: 1) a state intends to acquire nuclear weapons; and 2) that state acquires peaceful technology through invocation of Article IV sufficient to convert it at low cost to a nuclear weapons program.[180] At that point, the state can legally withdraw and proceed with its weapons program or simply proceed clandestinely.[181]

Any state that wants and can afford nuclear power need only become a signatory to the NPT, assuming the rest of the world is willing to abide by a good faith interpretation of the grand bargain. If the international community wishes to impose its will on a determined pre-

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[175] Iran is believed to be attempting to develop nuclear weapons. Albright, *supra* note 173. North Korea declared itself a de facto nuclear power in 2005. *N. Korea Says It Has Nuclear Arms*, WASH. POST, Feb. 10, 2005, at A16.

[176] There have been suggestions that the desire to avoid handing nuclear weapons to a black nationalist government may have been a motivating factor in the decision. SWEET, *supra* note 62, at 234 n.3.

[177] Although Israel has never confirmed that it possesses nuclear weapons, a recent slip of the tongue by Israeli Prime Minister Ehud Olmert lends credence to the almost universal belief that Israel possesses a nuclear arsenal. Greg Myre, *In a Slip, Israel's Leader Seems to Confirm its Nuclear Arsenal*, N.Y. TIMES, Dec. 12, 2006, at A5.

[178] Jonas, *supra* note 29, at 426.

[179] *Id.* at 424-25.

[180] *Id.*

[181] *Id.* Article X allows a party to withdraw from the treaty if the "supreme interests of its country" are jeopardized. NPT, *supra* note 2, art. X ¶ 1.

nuclear weapons state, then it must do so using traditional methods such as sanctions, conditional offers of aid, nuclear deterrence, or the threat of military action. Denial of nuclear technology, even if still an available option, has not proven to be an effective solution in similar situations.[182] More importantly, denial of nuclear technology to non-nuclear states closes the door to an effective method of reducing global warming.

C. IMPLEMENT A WORLDWIDE, FULL-PROCESSING FUEL CYCLE

As early as 1946, the United States proposed a program to place the nuclear fuel cycle under international control.[183] The Baruch Plan, presented to the United Nations Atomic Energy Commission, called for a system whereby primary production plants for nuclear fuel would be distributed worldwide under the control of the Atomic Energy Commission.[184] However, one of the things that Bernard Baruch insisted on avoiding in his plan was actual international ownership of nuclear materials and production.[185] In the end, the plan turned out to be too unrealistic and inflexible, which led to its veto by the Soviet Union, the only other nuclear power at the time.[186] Even though an international system of control for nuclear weapons material is unlikely ever to be resurrected, the idea of an international, or at least multinational, source of peaceful nuclear fuel production is still very much alive.

In a seminal paper first published in 1981, Lawrence Sheinman enumerated three possibilities for controlling the nuclear fuel cycle with an eye towards non-proliferation.[187] The first alternative was for the supplier states to guarantee a supply of nuclear materials, with an internationally controlled fuel bank, for example, as a fallback in case of a breach.[188] The second alternative was to have international oversight of domestic fuel cycles—essentially the current system under IAEA oversight.[189] The third option was for states to create multinational joint

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[182] Bajema & Nikitin, *supra* note 53, at 164-65.

[183] Bernard M. Baruch, U.S. Rep. on the U.N. Atomic Energy Comm'n, The Baruch Plan, presented to the U.N. Atomic Energy Comm'n (June 14, 1946), *available at* http://www.atomicarchive.com/Docs/Deterrence/BaruchPlan.shtml.

[184] *Id.*

[185] Weiss, *supra* note 42, at 37.

[186] *Id.*

[187] Lawrence Sheinman, *Multinational Alternatives and Nuclear Non-Proliferation*, 35 INT'L ORG. 77, 80 (1981).

[188] *Id.*

[189] *Id.*

ventures for controlling the nuclear fuel cycle.[190] Among these various options, Sheinman seems to prefer multilateral joint ventures, citing as exemplar success stories the various pan-European nuclear cooperation agreements.[191]

In 2003 Mohamed ElBaredei, Director-General of the IAEA, made a similar call for an end to closed domestic fuel cycles and a new era of multinational cooperation.[192] He called for limits on the processing of nuclear material in domestic nuclear programs, a system of proliferation-resistant reactors and fuels that would make it difficult to divert material to nuclear weapons programs, and a multinational system for managing nuclear materials and disposing of nuclear waste.[193] The advantages of such a system would be reduced cost, enhanced safety and security, and a reduction of the potential for proliferation of nuclear weapons.[194]

Establishment of multinational fuel processing programs modeled after the European experiment would be a step towards implementing the cost-saving, energy-efficient nuclear programs envisioned by the GNEP.[195] Concentrating fuel reprocessing facilities in a limited number of areas under multinational oversight would eliminate the redundancy of multiple processing centers and thereby increase the cost-effectiveness of nuclear energy. More importantly, reprocessing itself will increase the total amount of energy extracted from uranium ores, which in turn will enhance the efficiency of nuclear power generation.[196]

The problem, of course, is that a state determined to develop nuclear weapons would be reluctant to join a fuel processing consortium if it meant abandoning a domestic enrichment program that is crucial to its weapons program.[197] Such refusals, however, have the benefit of

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[190] *Id.*

[191] *Id.* at 80-81. The Euratom Supply Agency, for example, essentially places all European nuclear materials under the control of a single agency. *See* Euratom Supply Agency, Mission Statement, http://ec.europa.eu/euratom/mission_en.html (last visited Feb. 20, 2007).

[192] Mohamed ElBaredei, *Toward a Safer World*, ECONOMIST, Oct. 18, 2003, at 47, 48.

[193] *Id.*

[194] *Id.*

[195] *See supra* Part III.A.

[196] Hannum et al., *supra* note 154, at 88.

[197] For example, Iran has been reluctant to accept a proposal to enrich its nuclear fuel in Russia. Peter Finn, *Russia, Iran Still Talking on Fuel Enrichment Plan*, WASH. POST, Feb. 21, 2006, at A10.

making the intentions of the state to develop nuclear weapons more transparent.

Currently, the NPT does not forbid domestic processing of nuclear material and member states have not been barred from developing highly enriched uranium for use in experimental nuclear reactors.[198] Because of this, the statute of the IAEA should be amended to require participation in a multinational reprocessing system while at the same time outlawing domestic enrichment and reprocessing programs. Oversight by the IAEA would be authorized by its charter,[199] thus giving it a leading role in facilitating the creation of such multinational ventures. Although rogue states will continue to resist such schemes, it may be that the economic and environmental incentives will eventually be seen to outweigh the speculative benefits of becoming a nuclear weapons power. Thus, the "bargain" of multinational fuel processing is lower cost and more efficient nuclear power in exchange for fewer opportunities to develop nuclear weapons programs. The "bargain" of multinational fuel processing therefore provides a parallel enhancement of the "grand bargain" of the NPT while addressing the same proliferation concerns.

On a final note, one must account for the reality that global warming and nuclear proliferation are problems requiring a unified global solution. If the nuclear fuel cycle were governed by a program under multinational or international control, the probability of agreeing to a uniform, the worldwide fuel cycle would greatly increase. The result would be a maximally efficient global energy program that would simultaneously reduce GHG emissions, limit the amount of nuclear waste produced, and reduce the threat of nuclear weapons proliferation.[200]

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[198] Bajema & Nikitin, *supra* note 53, at 165-66.

[199] Statute of the IAEC, *supra* note 46, at art. III ¶ A.1 ("The Agency is authorized . . . to act as an intermediary for the purposes of securing . . . or the supplying of materials . . . by one member of the Agency for another").

[200] For example, global adoption of the pyrometallurgic process would require a sophisticated transition to advanced fast-neutron reactor designs. Hannum et al., *supra* note 154, at 89. The payoff would be a smaller amount of nuclear waste that will only be hazardous for five hundred years (as opposed to the ten thousand-year hazardous lifetime of current high level waste), on-site waste processing with no intermediate pure plutonium materials, and an extremely efficient use of uranium ore that could extend our resources almost indefinitely. *Id.* at 90.

VI. CONCLUSION

Nuclear energy production is an essential tool for reducing the level of GHGs worldwide while at the same time meeting the electricity demands of a developing world. Given the alternatives, it would be foolish not to embrace nuclear energy on an international scale. Although peaceful nuclear technology is a prerequisite for development of nuclear weapons programs, the solutions to the problem of nuclear weapons proliferation do not require dismantling existing nuclear reactors. On the whole, the environmental benefits of nuclear technology outweigh the risks of diversion of this technology into weapons programs.