

Nuclear Power: Problems and Solutions

Lynsey Ramos
December 2012

Table of Contents

I. Introduction	1
II. The Development of Nuclear Energy Regulation	2
<i>a) The Baruch Plan.....</i>	<i>2</i>
<i>b) The Atomic Energy Act.....</i>	<i>3</i>
<i>c) Atoms For Peace.....</i>	<i>4</i>
<i>d) The International Atomic Energy Agency</i>	<i>5</i>
<i>e) The Treaty on the Non-Proliferation of Nuclear Weapons</i>	<i>6</i>
III. The Relationship Between Nuclear Energy and Nuclear Weapons	9
<i>a) The Nuclear Fuel Cycle.....</i>	<i>9</i>
<i>b) The “Near Nuclear” States</i>	<i>10</i>
<i>c) Addressing Proliferation Concerns – Two Interpretations of the NPT.....</i>	<i>10</i>
<i>d) Proposed Amendments to the NPT.....</i>	<i>14</i>
IV. Legal Regulation of Nuclear Energy.....	17
<i>a) Nuclear Energy and the Law of War.....</i>	<i>18</i>
<i>b) Nuclear Energy and Environmental Conventions.....</i>	<i>19</i>
<i>c) Liability for Nuclear Accidents.....</i>	<i>21</i>
<i>d) Conventions on Safety</i>	<i>23</i>
<i>e) Challenges of Current Nuclear Energy Regulation.....</i>	<i>25</i>
V. Reducing the Risk of Proliferation.....	28
<i>a) Proposals for Increased International Oversight.....</i>	<i>28</i>
<i>b) Preventing Diversion and Terrorist Theft of Nuclear Materials.....</i>	<i>32</i>
<i>c) A New Breed of Reactor</i>	<i>33</i>
VI. The Necessity of Nuclear Power.....	35
<i>a) Alternatives to Nuclear Energy</i>	<i>35</i>
<i>b) A Nuclear Renaissance.....</i>	<i>40</i>
VII. Conclusion	41

I. Introduction

After several decades of stagnation, there has been a renewed global interest in nuclear power in recent years. New license applications for 30 reactors have been announced in the United States and another 548 reactors are under construction, planned, or proposed around the world.¹ In the United States, this trend is driven in part by tax credits and increasing concerns about carbon emissions from competing fossil fuel technologies.

The renewed interest in expanding the role of nuclear power in meeting the world energy demand, particularly in countries considering their first nuclear power plants, has also led to increased concerns about limiting the spread of nuclear weapons technology. This concern focuses on the nuclear fuel cycle, and in particular the enrichment of uranium and the separation and reprocessing of plutonium. Leaders of the international nuclear non-proliferation regime have suggested ways to limit the risk of countries adapting civilian nuclear energy technologies for military purposes, primarily through the creation of incentives not to enrich uranium or separate plutonium.² Because a major justification for building enrichment or reprocessing facilities is to ensure fuel supplies for a nation's nuclear power plants, many of these proposals focus on alternate ways to guarantee supplies of nuclear fuel. While efforts to limit the spread of nuclear technologies have foundered in the past, a growing concern about proliferation, particularly in light of the uncertainty surrounding Iran's nuclear program, as well as a growing consensus that the world must seek alternatives to high-pollution fossil fuels, make this a good time to reconsider strategies to limit access to the nuclear fuel cycle. To be successful, however, proposals must be attractive enough to compel states to forgo what they see as their inalienable right to develop nuclear technology for peaceful purposes. Improvements must also be made to

¹ MARY BETH NIKITIN, ANTHONY ANDREWS, & MARK HOLT, *MANAGING THE NUCLEAR FUEL CYCLE: POLICY IMPLICATIONS OF EXPANDING GLOBAL ACCESS TO NUCLEAR POWER* (Congressional Research Service, 2012).

² *Id.* at 1.

the International Atomic Energy Agency (“IAEA”) safeguards system and its means of detecting diversion of nuclear material to military programs. Finally, implementation of global safety standards must be considered, because as the number of reactors grows, the possibility of a nuclear accident that could have far-reaching international consequences also increases.

II. The Development of Nuclear Energy Regulation

a) The Baruch Plan

Beginning with the Baruch Plan in 1946, there have been numerous attempts to regulate and contain the global nuclear fuel cycle. Presented by Bernard Baruch before a session of the United Nations Atomic Energy Commission on June 14, 1946, the Baruch Plan marked the culmination of an effort to establish international oversight of the use of atomic energy in the hopes of avoiding unchecked proliferation of nuclear power after World War II. The Plan proposed the creation of an International Atomic Development Authority that would oversee all stages of the development and use of atomic energy, manage any nuclear facility with the ability to produce nuclear weapons and inspect any nuclear facility conducting research for peaceful purposes.³ The plan prohibited the possession of an atomic bomb and punished violators who interfered with inspections. The Development Authority would answer only to the Security Council, which would have the power to impose sanctions on nations that violated the terms of the plan. Critically, the Plan forbid the members of the Security Council from vetoing sanctions against nations that engaged in prohibited activities. Once the plan was fully implemented, the United States would begin the process of destroying its nuclear arsenal.⁴

The Soviets strongly opposed the plan, not only because it allowed the United States to retain its nuclear monopoly, but also because it did not wish to allow international inspections of

³ U.S. Department of State, Office of the Historian, Milestones: 1945-1952, <http://history.state.gov/milestones/1945-1952/BaruchPlans>.

⁴ *Id.*

Soviet nuclear facilities.⁵ The Soviets also rejected the idea of surrendering their Security Council veto. When a vote was held December 30, 1946, ten nations voted in favor of the Plan and two, Poland and the Soviet Union, abstained.⁶ Unanimity was required for the Plan to pass, and so the door was opened for the nuclear arms race to begin.

b) *The Atomic Energy Act*

After the Baruch Plan failed, the United States immediately passed legislation to regulate the national use of nuclear energy. The focus in 1946, with the passage of the Atomic Energy Act, was already on developing peaceful, rather than military, uses for the technology, at least publicly. The Act provided for the development and regulation of the uses of nuclear materials and facilities.⁷ All facilities and civilian uses of nuclear materials were to be licensed, and the Act empowered the Nuclear Regulatory Commission (“NRC”) to establish and enforce standards to govern these uses.⁸ “It was assumed from the beginning that information on peaceful applications of nuclear energy could be used to develop a weapons program” and so the government took steps to try and separate the two by regulating the various materials involved in the nuclear process.⁹

The Atomic Energy Act has been revised several times over the years to account for changing understandings of nuclear power and to provide for liability in the event of an accident. In 1957, for example, the Price-Anderson Act was enacted into law. Constituting Section 170 of the Atomic Energy Act, the main purpose of the Price-Anderson Act is to ensure the availability of a large pool of funds to provide prompt compensation to members of the public who are

⁵ *Id.*

⁶ *Id.*

⁷ 42 U.S.C. § 2011(1)(b).

⁸ 42 U.S.C. § 2201(b).

⁹ Richard Falk, *Denuclearization*, in *NUCLEAR POWER: BOTH SIDES: THE BEST ARGUMENTS FOR AND AGAINST THE MOST CONTROVERSIAL TECHNOLOGY* 229 (Michio Kaku, Ph.D. & Jennifer Trainer, eds., 1982).

injured in a nuclear or radiological incident, regardless of who might be liable.¹⁰ The Act requires NRC licensees and Department of Energy contractors to enter into agreements of indemnification to cover personal injury and property damage claims, including the costs of incident response and precautionary evacuation and the costs of investigating and defending claims for such damages.¹¹ The Act covers not only the operation of nuclear facilities, but also the transportation of nuclear fuel between facilities. Because the Act channels the obligation to pay compensation for damages, an injured party need not sue several entities, but can bring its claim directly to the licensee or contractor, significantly streamlining the process.¹²

c) *Atoms For Peace*

On December 8, 1953, President Eisenhower delivered a landmark speech to the U.N. General Assembly, calling for the dedicated pursuit of peaceful applications of nuclear materials and technology.¹³ Eisenhower called for atomic knowledge to be applied to “agriculture, medicine, and other peaceful activities” with a particular focus on providing “abundant electrical energy in the power-starved areas of the world.”¹⁴ This “Atoms For Peace” speech reflected the growing acceptance that nuclear materials and technology could be used for peaceful as well as destructive purposes on a global scale and could significantly benefit mankind in many ways. Eisenhower’s speech laid the groundwork for programs offering American help to countries developing nuclear programs, provided that the recipient nation would pledge not to use the information for weapons programs.¹⁵

¹⁰ 42 U.S.C. § 2210.

¹¹ *Id.*

¹² AMERICAN NUCLEAR SOCIETY, *THE PRICE-ANDERSON ACT* (2005).

¹³ United States Information Pertaining to the Treaty on the Non-Proliferation of Nuclear Weapons 20 (2010), <http://www.state.gov/documents/organization/141928.pdf>.

¹⁴ *Id.*

¹⁵ *Id.* at 21.

d) *The International Atomic Energy Agency*

In 1957, the IAEA was established to supervise a safeguards program designed to assure that sharing atomic information would not result in proliferation. The IAEA's role has evolved over the years, particularly with the passage of the Non-proliferation Treaty. Currently, one of the organization's important functions is to monitor operation of nuclear reactors and other facilities by non-nuclear weapon states with the aim of detecting, and thereby preventing, diversion of fissile materials, including plutonium and highly-enriched uranium, for use in weapons.¹⁶ The IAEA has one of the broadest international memberships in the field, has organized five multilateral conventions relating to nuclear safety, and is a leader in nuclear safety technology development.¹⁷

The IAEA was only one of the many organizations that would be formed to oversee developing nuclear energy programs. The European Atomic Energy Community (EURATOM) and the Organization for European Cooperation's European Nuclear Energy Agency were also formed around this time. They would be followed by multiple international agencies, all with a focus on regulating the safety, spread, and development of nuclear energy technology.¹⁸ However, the IAEA remains the most prominent in the field of international nuclear safety and technology, so it is often the institution that is the focal point of plans for building an international legal framework of safety coordination and development.

¹⁶ International Atomic Energy Agency, Our Work, <http://www.iaea.org/OurWork/>

¹⁷ Karen McMillan, *Strengthening the International Legal Framework for Nuclear Energy*, 13 GEO. INT'L ENVTL. L. REV. 983, 989 (2001).

¹⁸ These include the Agency for Prohibition of Nuclear Weapons in Latin America, the Inter-American Nuclear Commission, the World Association of Nuclear Operators, and the OECD/Nuclear Energy Agency, to name just a few.

e) *The Treaty on the Non-Proliferation of Nuclear Weapons*

Then, in 1968, one of the most important pieces of legislation regulating nuclear technology was enacted. The Treaty on the Non-Proliferation of Nuclear Weapons (“NPT”) was adopted in response to the increasing number of countries developing nuclear weapons and nuclear energy technology. Initially, countries contemplating the acquisition of nuclear weapons refused to sign the treaty, but many would eventually come on board, some even relinquishing their small nuclear arsenals in the process. To date, a total of 190 parties have joined the NPT, including the five recognized nuclear-weapon states.

The treaty entered into force on March 5, 1970 and was extended indefinitely on May 11, 1995. It is commonly described as having three main “pillars”: non-proliferation, disarmament and peaceful use of nuclear technologies. Of particular concern here is Article IV, which gives states the right to develop nuclear technologies for non-military purposes.

Article IV(2) of the NPT, which states, in part:

“All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy.”¹⁹

has been interpreted to allow all states to develop the full nuclear fuel-cycle without restriction.²⁰

This includes uranium enrichment and plutonium reprocessing capabilities. It is crucial to note that this “inalienable right” is not a right granted by the NPT, but rather a right inherent in state sovereignty that is recognized by the NPT, subject to the obligation not to “manufacture” nuclear

¹⁹ Treaty on the Non-Proliferation of Nuclear Weapons art. 4, July 1, 1968, 79 U.N.T.S. 161.

²⁰ Michael Spies, *Iran and the Nuclear Fuel Cycle*, in NUCLEAR DISORDER OR COOPERATIVE SECURITY? U.S. WEAPONS OF TERROR, THE GLOBAL PROLIFERATION CRISIS, AND PATHS TO PEACE: AN ASSESSMENT OF THE FINAL REPORT OF THE WEAPONS OF MASS DESTRUCTION COMMISSION AND ITS IMPLICATIONS FOR U.S. POLICY 138-39 (Michael Spies & John Burroughs eds., 2007).

weapons.²¹ There are many reasons a country may want to develop these technologies that are not related to military uses, including ensuring access to nuclear fuel, but there is concern that possessing these capabilities places a country within easy reach of developing a nuclear weapon and thus makes them a potential threat to the rest of the world.

In order to respond to proliferation concerns, several preventative measures have been put in place, including safeguards monitored by the IAEA, export control regimes and prohibitions on the production of fissile materials worldwide. Each non-nuclear weapons state under the NPT has to enter into a safeguards agreement with the IAEA that requires the state to declare its nuclear facilities and activities.²² IAEA inspectors verify these declarations through onsite inspections, which may include auditing the facility's accounting, verifying the nuclear material inventory, or collecting environmental samples.²³ The safeguards are a way for the IAEA to ensure that a state is living up to its international commitments not to use peaceful nuclear programs for nuclear weapons purposes. The system functions as an early warning mechanism and "the trigger that sets in motion other responses by the international community if and when the need arises."²⁴ The IAEA has also instituted additional safety measures in the years since the NPT was adopted. The Additional Protocol, which was proposed in response to fears about clandestine nuclear activities after it was revealed that Iran was developing uranium enrichment facilities, allows for more intrusive inspections and obligates states to provide additional information about their activities to the IAEA. The Protocol was meant to enhance nuclear non-proliferation by strengthening the effectiveness and improving the efficiency of the

²¹ Treaty on the Non-Proliferation of Nuclear Weapons arts. 3 & 4, July 1, 1968, 79 U.N.T.S. 161.

²² *Id.* at art. 3.

²³ IAEA Safeguards Overview: Comprehensive Safeguards Agreements and Additional Protocols (2012), http://www.iaea.org/Publications/Factsheets/English/sg_overview.html.

²⁴ *Id.*

IAEA's existing safeguards system.²⁵ Under the Additional Protocol, the IAEA is granted broader access to sites, is empowered to collect soil, water and atmosphere samples for detection of nuclear elements, and has the right to obtain information on the so-called "dual-use" materials that present the greatest risk of diversion for use in nuclear weapons.²⁶ Overall, the Protocol is designed to allow the IAEA to not only verify the non-diversion of declared nuclear material, but also to provide assurances as to the absence of undeclared nuclear activities and materials in the state.²⁷

One of the limitations of these safeguards is that they only apply to non-nuclear weapon states. The nuclear weapon states abide only by voluntary safeguard agreements. Another issue is that the safeguards agreement and Additional Protocol have not been adopted by all member states and do not apply at all to those countries outside of the NPT. This leaves large gaps in the IAEA's ability to ensure that all nations, particularly those that present the largest proliferation risk, are adequately and accurately accounting for their nuclear materials.

The NPT has done a reasonably good job of preventing the spread of nuclear weapons. Serious efforts to acquire nuclear weapons in violation of the treaty are known or suspected to have occurred in only a handful of cases, including Iraq, Libya and North Korea. Iran is also suspected of pursuing uranium enrichment capabilities that would enable it to independently fuel nuclear reactors or potentially make nuclear weapons, but it is unclear whether this is in violation of its obligations under the treaty given the broad provisions of Article IV.²⁸ The necessity of maintaining a balance between the rights and obligations of states and the desire to prevent

²⁵ FABRIZIO NOCERA, *THE LEGAL REGIME OF NUCLEAR ENERGY: A COMPREHENSIVE GUIDE TO INTERNATIONAL AND EUROPEAN UNION LAW* 597 (Oxford 2005).

²⁶ *Id.*

²⁷ IAEA Safeguards Overview: Comprehensive Safeguards Agreements and Additional Protocols (2012), http://www.iaea.org/Publications/Factsheets/English/sg_overview.html.

²⁸ John Burroughs, *The Nuclear Non-Proliferation Treaty*, in *NUCLEAR DISORDER OR COOPERATIVE SECURITY?*, *supra* note 20, at 28.

proliferation presents one of the greatest difficulties in matters of compliance assessment and enforcement under the NPT and, as discussed below, has led to two distinct views about how the NPT should be interpreted and applied.²⁹

III. The Relationship Between Nuclear Energy and Nuclear Weapons

a) The Nuclear Fuel Cycle

There is a critical need to closely regulate nuclear energy, because the connection between peaceful and military uses of the technology is too apparent to ignore. The nuclear fuel cycle presents two points of concern for critics. The first occurs at the front-end of the cycle, the enrichment stage. The vast majority of the world's power reactors use uranium fuel enriched to about 3.5% U-235, also known as low-enriched uranium, or LEU.³⁰ At this level of enrichment, the material cannot be used in bombs.³¹ However, with some adjustments, the same facilities and equipment used to produce the LEU fuel for power reactors can produce uranium with a concentration of over 90% U-235, also called high-enriched uranium, or HEU. This material is suitable for direct use in a nuclear weapon.³²

The second area of concern involves the spent fuel rods after they are removed from the reactor. Reprocessing or disposing of the plutonium that is produced as a by-product of power generation in some reactors presents a serious challenge. All plutonium separated from spent nuclear fuel is directly useable in nuclear weapons, and protecting this material is a serious concern from a non-proliferation prospective.³³ Currently, only a handful of countries possess the technology to refine the uranium for use in reactors or to dispose of or reprocess the spent

²⁹ Spies, *supra* note 20, at 139.

³⁰ Michael Spies, *Controlling the Nuclear Fuel Cycle*, 31 DISARMAMENT TIMES 1, 6 (2008).

³¹ *Id.*

³² *Id.*

³³ *Id.*

fuel – the two elements of the process that cause the most concern for critics of nuclear power – but more are actively seeking to develop these technologies.³⁴

b) *The “Near Nuclear” States*

One of the greatest proliferation threats lies in the development of uranium enrichment and reprocessing technologies, since these processes offer the country that has them direct access to the materials needed to produce a nuclear weapon. Eight countries, Russia, the United States, France, the United Kingdom, the Netherlands, Germany, China and Japan are recognized as having the capacity to enrich uranium. Pakistan, India, Brazil and Iran also have, or are suspected of having, this technology.³⁵ There is also some speculation that Argentina, South Africa and possibly Israel may be developing an independent enrichment capability.³⁶ Several of these same countries, including China, France, the United Kingdom, India, Japan, Pakistan, Russia, and the United States, also have reprocessing sites, and thus theoretically have access to weapons-grade plutonium.³⁷ While many of these countries are recognized nuclear powers, others are considered “near nuclear” because they have the ability to develop a bomb at any time.

c) *Addressing Proliferation Concerns – Two Interpretations of the NPT*

The right of countries to develop enrichment and reprocessing facilities is based on the broad language of Article IV of the NPT, which states in part, that parties have an “inalienable right” to “develop research, production and use of nuclear energy for peaceful purposes.”³⁸ Some countries, including the United States and many of the non-nuclear weapons parties to the treaty, argue that this language creates a clear right for countries to develop all stages of the

³⁴ *Id.* at 1.

³⁵ World Nuclear Association, Uranium Enrichment (2012), <http://www.world-nuclear.org/info/inf28.html>.

³⁶ Spies, *supra* note 30, at 8, fn1.

³⁷ World Nuclear Association, Processing of Used Nuclear Fuel (2012), <http://www.world-nuclear.org/info/inf69.html>.

³⁸ Treaty on the Non-Proliferation of Nuclear Weapons art. 4(1), July 1, 1968, 79 U.N.T.S. 161.

nuclear fuel cycle as part of a peaceful nuclear energy program, provided they do not divert the materials for use in weapons and comply with IAEA safeguards under Article III.³⁹ This, it is argued, is the “grand bargain” of the treaty. Non-nuclear states, in exchange for their promise not to develop nuclear weapons, are guaranteed the right to use and to receive assistance in, peaceful civilian nuclear energy.⁴⁰ This bargain is essential to the entire NPT regime because it provides countries with the necessary incentive to follow non-proliferation norms. Otherwise, the NPT would be a treaty that asks parties to reduce military power without a corresponding benefit.

Critics of this approach point out that the NPT is, at its core, a non-proliferation treaty, and that to apply the interpretation above would be to grant parties the right to come to the very cusp of obtaining a nuclear weapon under the auspices of the treaty, the very antithesis of its non-proliferation aims. In addition to granting an inalienable right, Article IV also states that that right must be exercised “in conformity with Articles I and II of this Treaty,” which, among other things, ban non-nuclear weapons states from seeking or receiving “any assistance in the manufacture of nuclear weapons.”⁴¹ This qualification not only narrows the scope of nuclear energy for peaceful purposes to which signatories have an inalienable right, but also establish criteria, such as compliance with Article III, that parties must meet in order to exercise this right.⁴² Essentially, if the IAEA cannot effectively safeguard the nuclear material involved, as

³⁹ John Gray, *Choosing the Nuclear Option: The Case for a Strong Regulatory Response to Encourage Nuclear Energy Development*, 41 ARIZ. ST. L.J. 315, 337 (2009); Henry Sokolski, *The Nuclear Nonproliferation Treaty’s Untapped Potential to Prevent Proliferation*, in REVIEWING THE NUCLEAR NONPROLIFERATION TREATY 9 (Henry Sokolski ed., 2010).

⁴⁰ Gray, *supra* note 39, at 337.

⁴¹ Treaty on the Non-Proliferation of Nuclear Weapons arts. 2 & 4(1), July 1, 1968, 79 U.N.T.S. 161.

⁴² Robert Zarate, *The Three Qualifications of Article IV’s “Inalienable Right”*, in REVIEWING THE NUCLEAR NONPROLIFERATION TREATY 219 (Henry Sokolski ed., 2010).

required under Article III, then the NPT does not protect the right of states to develop, access, or use that allegedly peaceful nuclear technology.⁴³

Along similar lines, the argument has been made that, at some point, particular assistance or activities may become so risky, that they can no longer be deemed in conformity with the requirements of Articles I and II, even though by their stated terms they are for peaceful power applications only.⁴⁴ The “inalienable right” of Article IV thus remains subordinate to the prohibitions of Articles I and II, and if the practical consequences of the assistance or activity are likely to lead to the proliferation of nuclear weapons, non-nuclear weapons states do not have a right of access. Uranium enrichment and plutonium reprocessing, according to this view, are clearly activities that present such a great risk of proliferation that their spread should be disallowed under this interpretation of the treaty.

For these critics of the “absolute right” approach, the situation in North Korea highlights the danger of interpreting the treaty to allow countries to obtain nuclear technologies unfettered. Countries can demand their sovereign right to possess nuclear technology pursuant to Article IV, yet secretly use that same technology as part of a nuclear weapons program.⁴⁵ When they are close to developing a weapon, they simply withdraw from the treaty and within a very short period of time, become a nuclear weapons state.

A similar situation is ongoing with Iran. International inspectors have chronicled a multi-year history of reporting violations and clandestine nuclear activities in Iran related to the

⁴³ *Id.* at 225.

⁴⁴ Eldon V.C. Greenberg, *Peaceful Nuclear Energy and the Nuclear Nonproliferation Treaty*, in *REVIEWING THE NUCLEAR NONPROLIFERATION TREATY* 107 (Henry Sokolski ed., 2010).

⁴⁵ Chris Peloso, *Crafting an Updated Nuclear Non-Proliferation Treaty: Applying the Lessons Learned from the Success of Similar International Treaties to the Nuclear Arms Problem*, 9 *SANTA CLARA J. INT’L L.* 309 (2011).

development of the nuclear fuel-cycle technologies.⁴⁶ Iran claims that it is developing these technologies for peaceful purposes, pursuant to its Article IV rights. However, the gas centrifuges that Iran is building for the stated purpose of enriching uranium to low levels for use as nuclear fuel can also be used to create the high enrichment uranium needed for nuclear weapons.⁴⁷ Iran has been found non-compliant with the NPT, but it seems to be Article III, and not Article IV, that it has violated. It is clear that Iran's concealment of activities resulted in violations of its Safeguards Agreement but it is not as clear whether Article IV was also violated because of the variable interpretations of what the inalienable right under the treaty actually entails.

One drawback of the more limited interpretation of Article IV is that there are no provisions for how such an approach would be implemented, who would determine when a technology is forbidden, or how states would be prohibited from developing these technologies. Interestingly, although a complete ban on nuclear power would seem to flow from this argument, particularly in light of the non-proliferation treaty's disarmament goals, no critic has presented that interpretation. The focus instead seems to be on leaving enrichment and reprocessing technologies in the hands of a few countries, most often those who already have them, and those countries will provide fuel, but not the technological information on how to make it, to the nations that wish to develop civilian nuclear energy. Unfortunately, this only serves to broaden the gaps between the nuclear "haves" and "have-nots" and is unlikely to be an attractive proposition for those countries who have already agreed to give up developing nuclear weapons. This interpretation of the treaty also completely fails to consider the fact that the only countries that are known to have used nuclear energy technology to develop nuclear weapons either were

⁴⁶ International Atomic Energy Agency, Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran: Report of the Director General ¶ 4, GOV/2005/67 (2005).

⁴⁷ Gray, *supra* note 39, at 337.

never part of the treaty or withdrew. Interpreting the NPT to allow only some countries to have access to reprocessing and enrichment technologies would not prevent countries who are most likely to develop these technologies for weapons purposes from doing so, and does not address the issue that if countries decided they wanted these technologies, all they would have to do is withdraw from the treaty.

This interpretation also overlooks serious social and political concerns that are often driving nations to develop these technologies in the first place, not the least of which is a desire for energy security. A country looking to ensure a steady supply of fuel for nuclear reactors that cannot be disrupted by social or political uprisings elsewhere might very well be inclined to develop enrichment and reprocessing technologies, even if they seem economically unviable at the time. This is particularly true for some nations in the Middle East, who may feel that if reprocessing and enrichment technologies are left solely in the hands of Western nations, there is a legitimate fear that a time may come where fuel is withheld for political leverage. In light of these concerns, it is difficult to believe that non-nuclear weapons states would ever embrace an interpretation of the treaty that results in them abandoning not only the right to develop nuclear weapons, but also the right to develop nuclear technologies for peaceful purposes and instead be content to leave all of this knowledge and power in the hands of the nuclear weapons states. Such a proposition seems politically unfeasible. For now, at least, the current interpretation of Article IV is likely to prevail.

d) Proposed Amendments to the NPT

To address the dual-use problem posed by nuclear materials such as uranium and plutonium and in an attempt to curb proliferation, some amendments to the NPT have been suggested, but they tend to focus on ways to strengthen protection of nuclear materials and not

on limiting access to nuclear energy technologies. Proposed amendments include providing international guarantees of fuel supply for civilian nuclear reactors in countries not producing fuel, using LEU instead of HEU for civilian purposes and prohibiting attacks on nuclear installations.⁴⁸ There have also been calls for more intrusive nuclear inspection procedures, increased IAEA safeguards funding, and automatic penalties for safeguards agreement violations, but not for abolishment of the right to nuclear energy.⁴⁹ In fact, this is a right that has been affirmed again and again.

At the 2012 Preparatory Conference held in Vienna, in preparation for the 2015 NPT Review Conference, the planning group recognized the benefits of the peaceful uses of nuclear energy and called for the IAEA's functions to be further enhanced to create better cooperation among the states parties.⁵⁰ The Arab states submitted a working paper on the peaceful use of nuclear energy, reiterating that any attempt to restrict the right to peaceful nuclear energy is prohibited.⁵¹ Iran and China also referenced this in their joint working paper.⁵² Similar assertions were made at the 2010 Review Conference.⁵³ It was agreed that any development of nuclear energy must be accompanied by further implementation of IAEA safeguards, but there was no contention that countries did not have the right to develop nuclear energy, or that that right was somehow limited by the risks of proliferation that it posed.⁵⁴

⁴⁸ JOZEF GOLDBLAT, AMENDING THE NON-PROLIFERATION REGIME (2009), <http://unidir.org/pdf/articles/pdf-art2862.pdf>.

⁴⁹ Sokolski, *supra* note 39, at 6.

⁵⁰ NTI, TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS (2011), <http://www.nti.org/treaties-and-regimes/treaty-on-the-non-proliferation-of-nuclear-weapons>.

⁵¹ *Id.*

⁵² *Id.*

⁵³ *Id.*

⁵⁴ *Id.*

Even if an amendment to limit access to nuclear technologies were formally proposed, it is unlikely to be successful. The NPT is notoriously difficult to amend.⁵⁵ Article VIII of the NPT provides a process for amendment and states “[a]ny Party to the Treaty may propose amendments to the Treaty.”⁵⁶ However, any proposed amendment must be approved by a majority vote, including all of the nuclear weapons states and all of the parties that are currently members of the Board of Governors of the IAEA. This makes the treaty difficult to amend and makes amendments to Article IV, should any be suggested, particularly challenging, because the majority of the treaty’s signatories are non-nuclear weapons states for whom the benefit of the treaty is the economic and social power that comes from the ability to develop nuclear energy for peaceful purposes. In fact, to date, the treaty text has never been amended.⁵⁷

Although amendments to the Treaty seem an unlikely avenue for change, something must be done to address the connection between nuclear weapons and nuclear power, especially in light of the nuclear weapons states’ obligation to disarm under the NPT. If the disarmament obligations of these countries are taken seriously, then the continued existence of nuclear power facilities raise serious concerns for the viability of a nuclear weapons free world, particularly if these technologies continue to spread freely. However, because it seems unlikely that countries will agree to relinquish the right to nuclear energy completely while countries continue to possess nuclear weapons, other steps must be taken to ensure that the risk of proliferation is minimized, even if it cannot be eliminated at the present time, and that nuclear facilities are as safe and secure as possible.

⁵⁵ Sokolski, *supra* note 39, at 4 (“amending the treaty is nearly impossible”).

⁵⁶ Treaty on the Non-Proliferation of Nuclear Weapons art. 8, July 1, 1968, 79 U.N.T.S. 161.

⁵⁷ Peloso, *supra* note 45, at 341.

One possible solution that might be implemented within the current framework of the NPT comes from the Chemical Weapons Convention, which also must contend with a dual-use problem. There, the drafters created a sliding scale whereby technologies and chemicals of highest proliferation concern are subject to significant restrictions and intrusive verification measures, while technologies and chemicals of lower proliferation concern are subject to lesser restrictions.⁵⁸ Much of the necessary data about more and less dangerous nuclear technologies already exists in the IAEA Model Safeguards agreement.⁵⁹ It would simply be a matter of adopting the Agreement as a Protocol or Annex to the NPT. There are also other legal and technological solutions that might be instituted, on top of the current framework, in order to combat proliferation as well as safety risks presented by nuclear facilities.

IV. Legal Regulation of Nuclear Energy

Like all forms of energy production, there is no question that there are risks associated with nuclear energy. In addition to concerns about proliferation, one of the most feared risks is a “meltdown” where the core of a nuclear power plant overheats and radiation is released into the air, resulting in local, regional and potentially global contamination. The three most famous examples of nuclear accidents are Three Mile Island in the United States,⁶⁰ Chernobyl in Ukraine,⁶¹ and, most recently, Fukushima in Japan.⁶² In all of these accidents, radiation was

⁵⁸ *Id.* at 338.

⁵⁹ *Id.* at 339.

⁶⁰ On March 28, 1979, the core partially melted in Unit 2 at Three Mile Island due to a faulty valve and operator error. Emissions into the atmosphere have been classified as limited, but the exact extent of contamination is unknown. No one at the plant or in the nearby community was injured or killed, but the incident brought about sweeping changes to operator training, emergency response planning, and many other areas of nuclear power plant operations. United States Nuclear Regulatory Commission, Background on the Three Mile Island Accident (2009), <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>; Franco Romerio, *Nuclear Energy between Past and Future: An Assessment Based on the Concept of Risk*, 8 COMPETITION AND REGULATION IN NETWORK INDUSTRIES 1, 40 (2007).

⁶¹ On April 26, 1986, the core of the nuclear plant at Chernobyl melted releasing large amounts of radioactivity into the environment. The disaster was caused by weak technological design and operator error. More than 116,000 people had to be evacuated from within a 30-kilometer radius of the plant and 220,000 were eventually relocated.

released in varying degrees into the atmosphere. There is substantial debate about the extent of the release in these cases. Part of the challenge with nuclear accidents is that the effects can be hard to measure because they often occur over a large span of time and can be difficult to separate from naturally occurring events.⁶³ For example, radiation contamination most often appears in the form of cancer cases or birth defects, both of which are naturally occurring in a population and therefore can be difficult to link directly to a nuclear accident. Incidents will increase with radiation exposure and scientists must try and measure exactly how much has changed, often years after an accident, when trying to quantify the disaster's ultimate impact. This often leads to very disparate accounts of damage from nuclear accidents. Regardless, when radiation is released, there can be significant economic, environmental, and social damage and a legal regime has arisen to try and address plant safety and liability for these damages.

a) *Nuclear Energy and the Law of War*

The uncontrollable spread of radiation that could result should a plant's protection systems fail would seem to invoke the same concerns that are presented by the use of a nuclear weapon during war. Under the laws of war, the rule of discrimination prohibits the use of a

At the time, the clouds of radiation that spread from the disaster site affected vast regions of the Northern hemisphere and its effects continue to be felt today. Nuclear Energy Agency and Organisation for Economic Co-Operation and Development, *Comparing Nuclear Accident Risks with Those from Other Energy Sources* 17 (2010); World Nuclear Association, *Chernobyl Accident 1986* (2012), <http://www.world-nuclear.org/info/chernobyl/inf07.html#e>.

⁶² On March 11, 2011, a magnitude 9.0 earthquake struck Japan. A tsunami also struck the area, destroying transmission lines to the Fukushima Daiichi nuclear power station and engulfing the plant's standby generators, rendering the regular and emergency cooling systems inoperable for all six reactors as well as the spent fuel pools. The Japanese government was forced to evacuate some 140,000 residents from the surrounding area due to the radiation threat. Although some radiation escaped into the atmosphere, there is debate about how large of an impact it will have on the surrounding population. Anywhere from 100 – 1,500 cancer deaths have been estimated and these numbers may change as the impact of the disaster is better understood in the future. Stephen L. Kass, *International Law Lessons From the Fukushima Nuclear Disaster*, N.Y.L.J., April 29, 2011; Richard Muller, *The Panic Over Fukushima*, WALL ST. J., August 18, 2012, at C2.

⁶³ Phoebe Okowa, *The Legacy of Trail Smelter in the Field of Transboundary Air Pollution*, in *TRANSBOUNDARY HARM IN INTERNATIONAL LAW: LESSONS FROM THE TRAIL SMELTER ARBITRATION* 202 (Rebecca M. Bratspies & Russel A. Miller eds., 2006) ("Late effects are usually indistinguishable from diseases induced by other causes and radiation only increases their incidence in the population.").

weapon that cannot discriminate in its effects between a military and civilian target. This rule also encompasses the inherent effects of a weapon, like, arguably, the spread of radiation.⁶⁴ The impact of a nuclear power plant disaster is virtually the same as that of a nuclear weapon. Both are indiscriminate in their effects and both produce a radiation cloud that is unpredictable and uncontrollable in time and space. Unlike a nuclear weapon, however, which, when used, will undoubtedly release radiation, a nuclear power plant can operate for decades without any radioactive release. It seems unlikely that countries will invoke the rule of discrimination to prevent the use of nuclear power when the effects that the rule is meant to protect against are so attenuated.

The principle of neutrality might also be invoked if one considers the radiation cloud a dangerous instrumentality. This principle protects neutral territories from entry, not only of troops, but also “instrumentalities of war.”⁶⁵ There is a question, however, whether this principle would apply to radioactive fallout from use of a weapon during wartime, and so extension to a non-military application seems a nearly impossible stretch at this time.

While the laws of war may not apply to the nuclear energy context, the international community has not left countries without recourse. Instead, nuclear energy has been incorporated as part of laws and treaties that apply to environmental pollution, such as carbon emissions, which can also cross international borders and cause devastating health effects and long-lasting environmental damage.

b) Nuclear Energy and Environmental Conventions

The general principal of international environmental law is that no state has the right to use or permit the use of its territory in such a manner as to cause injury on or to the territory of

⁶⁴ CHARLES J. MOXLEY, JR., NUCLEAR WEAPONS AND INTERNATIONAL LAW IN THE POST COLD WAR WORLD 66 (Austin & Winfield 2000)

⁶⁵ *Id.* at 75, citing U.S. Army Field Manual 27-10, The Law of Land Warfare 1956, at 185.

another or the properties or persons therein.⁶⁶ This principle is reflected in customary international law and has been endorsed as “part of the corpus of international law on the environment” by the International Court of Justice.⁶⁷ Several conventions have specifically applied this principle to nuclear energy.⁶⁸ Most prominently, the Convention on Environmental Impact Assessment in a Transboundary Context directs parties to “take all appropriate and effective measures to prevent, reduce and control significant adverse transboundary environmental impact” through legal, administrative and other measures, including undertaking an environmental impact assessment before authorizing any potentially hazardous activity.⁶⁹ The Convention also requires a party to inform others who may be affected about the proposed activity.⁷⁰ This Convention specifically applies to nuclear power stations and facilities for the production, enrichment and reprocessing of nuclear fuels.⁷¹

The emergence of obligations to take preventative or mitigating measures is especially prominent in the field of environmental law.⁷² States must take concrete steps in order to protect the environment and public health before any damage occurs.⁷³ This obligation seeks to reconcile one state’s right to use its territory and resources with another state’s right to be free

⁶⁶ Gunther Handl, *Trail Smelter in Contemporary International Environmental Law: Its Relevance in the Nuclear Energy Context*, in *TRANSBOUNDARY HARM IN INTERNATIONAL LAW*, *supra* note 63, at 126-27.

⁶⁷ *Legality of the Threat or Use of Nuclear Weapons*, Advisory Opinion, 1996 I.C.J. 226, para. 29 (July 8).

⁶⁸ *See also*, Draft Articles on Prevention of Transboundary Harm from Hazardous Activities, Report of the ILC on the Work of its Fifty-third Session, 2001, appearing in Official Records of the General Assembly, Fifty-sixth Session, Supp. No. 10, A/56/10. The Articles set forth the proposition that the freedom of States over the natural resources within their territory is not unlimited. States must take all appropriate measures to either prevent or minimize the risk of significant transboundary harm. This can include legislative, administrative or other action, including establishing suitable monitoring mechanisms. The Articles also contain a notice provision and suggests that a state must wait for any state that may be affected by the risky activity to respond before authorizing the activity.

⁶⁹ The Convention on Environmental Impact Assessment in a Transboundary Context art. 2(1)-(3), Feb. 25, 1991, 1989 U.N.T.S. 309.

⁷⁰ *Id.* at art. 3.

⁷¹ *Id.* at appx I(2)-(3).

⁷² Gerhard Hafner & Isabelle Buffard, *Obligations of Prevention and the Precautionary Principle*, in *THE LAW OF INTERNATIONAL RESPONSIBILITY* 521 (James Crawford, Alain Pellet, & Simon Olleson, eds., 2010).

⁷³ *Id.* at 524.

from harm as a result of that use. At the extreme end of the spectrum, this heightened standard of care might force the conclusion that the activity itself would be impermissible, but international law has so far failed to define the outer limits of permissible risk-creation and has instead provided maximum leeway for states to engage in risky conduct.⁷⁴ There are also concerns with the lack of oversight of national efforts to regulate transboundary air pollution. Parties are given wide latitude in deciding what methods to employ in complying with the obligation to mitigate potential damage.⁷⁵ For example, in the 1979 U.N. Economic Commission for Europe Convention on Long-range Transboundary Air Pollution, the parties are required to do no more than endeavor to limit and to gradually reduce the amount of air pollution emanating from their territories.⁷⁶ How they do this is entirely up to the parties and there are no provisions for mandatory external review should a regulatory scheme prove inadequate.⁷⁷ As a result, there is a possibility for broad interpretation of the obligations that undermines the desire for consistency and reliability that is at the heart of these conventions.

c) *Liability for Nuclear Accidents*

In the event an accident does occur, the international community and the United States have opted to hold the operator of a plant liable for injury done to parties by any radioactive releases.⁷⁸ As a matter of customary international law, there is no general principle providing for the responsibility of a State in the absence of an internationally wrongful act, even if the damage

⁷⁴ Handl, *supra* note 66, at 138.

⁷⁵ Okowa, *supra* note 63, at 209.

⁷⁶ Convention on Long-range Transboundary Air Pollution, Nov. 13, 1979, 1302 U.N.T.S. 217.

⁷⁷ Okowa, *supra* note 63, at 208.

⁷⁸ Kass, *supra* note 62. The IAEA has also supported two conventions on liability for nuclear damage that aim to improve international nuclear safety by threatening operators with potential liability: the 1963 Vienna Convention on Civil Liability for Nuclear Damage and the Convention on Supplementary Compensation for Nuclear Damage. *See also*, the Price-Anderson Act, *supra* pgs. 3-4.

caused is of an environmental nature.⁷⁹ There are, however, treaties that establish liability for any damage caused by a civil nuclear accident.⁸⁰ For example, under the OECD Paris Convention on Third Party Liability in the Field of Nuclear Energy, the operator is obligated to subscribe to insurance covering the entire amount of possible responsibility in the event of an accident.⁸¹ This Convention and others like it establish minimum thresholds for the responsibility of nuclear operators. However, it is up to the parties to the conventions to impose internal laws that can, to some extent, modify the maximum and minimum liability amounts establish in the conventions, as well as the statute of limitations for bringing a claim.⁸² It is also up to the tribunals in the nation where the incident occurred to settle any disputes that may arise regarding liability. In fact, only the tribunals of the place where the damaging incident occurred are empowered to deal with resulting legal actions.⁸³ This can create problems, particularly with radiation where the effect is unpredictably widespread and where many nations may be affected. Fortunately, the viability of these schemes has never been tested, because of the small number of nuclear incidents.

Although the risk of a nuclear accident may be small, it only takes one to have devastating consequences for the country and, if the accident is severe enough, for surrounding nations. Given the possibility of severe damage, treaties on liability and environmental damage general are not sufficient. The IAEA, recognizing the need for enhanced safety standards in the nuclear context, has respond by promulgating numerous safety conventions that address both pre- and post-accident responsibilities of nations.

⁷⁹ Michel Montjoie, *Nuclear Energy*, in THE LAW OF INTERNATIONAL RESPONSIBILITY, *supra* note 72, at 915.

⁸⁰ Philippe Guttinger, *Allocation of Responsibility for Harmful Consequences of Acts Not Prohibited by International Law*, in THE LAW OF INTERNATIONAL RESPONSIBILITY, *supra* note 72, at 516.

⁸¹ Christian Tomuschat, *The Responsibility of Other Entities: Private Individuals*, in THE LAW OF INTERNATIONAL RESPONSIBILITY, *supra* note 72, at 323.

⁸² *Id.* at 324.

⁸³ *Id.*

d) *Conventions on Safety*

The IAEA has been instrumental in orchestrating five conventions related to nuclear safety that try to address some of the transnational risks posed by the operation of nuclear power plants, three of which are discussed here. These conventions are multilateral in scope and compliment the numerous bilateral and regional agreements on nuclear safety.⁸⁴ The Convention on Early Notification of a Nuclear Accident, for example, aims to strengthen international cooperation in order to provide relevant information about nuclear accidents as early as possible to minimize the consequences of the spread of radiation. The convention, which was prompted by the events at Chernobyl and entered into force on October 27, 1986, applies to all nuclear facilities, including nuclear reactors, fuel cycle facilities, and waste management plants.⁸⁵ Parties to the convention commit to notifying the IAEA and countries that may be affected by the accident and to providing information on the development of the accident. Although this agreement does not prevent accidents from occurring, it improves overall safety by assuring an adequate response to nuclear accidents.

The Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency is significant in that it coordinates accident assistance. If a country needs help, it may call on the IAEA for assistance.⁸⁶ The convention requires parties to inform the IAEA of their existing equipment and experts, and the IAEA then coordinates necessary services and resources to assess and respond to the accident.⁸⁷ This convention complements the existing international safety regime by ensuring a swift response in the event of an emergency and reducing the

⁸⁴ Nuclear Energy Agency, *Nuclear Energy Today* 67 (2003). The bilateral agreements on cooperation involve such matters as the exchange of technical information and specialists, the provision of materials and equipment for experiments, and provisions for joint research into aspects of safety and radiological protection.

⁸⁵ International Atomic Energy Agency, *Convention on Early Notification of a Nuclear Accident*, November 8, 1986.

⁸⁶ McMillan, *supra* note 17, at 991.

⁸⁷ *Id.*

environmental harm caused by nuclear accidents. “Strong response teams help mitigate nuclear damage when prevention methods fail,” but the convention is weakened by the fact that assistance is voluntary, so other countries, including those with the needed expertise, may refuse to provide help.⁸⁸

Arguably the most significant agreement in terms of improving the safe operation of nuclear power plants is the Convention on Nuclear Safety, which entered into force on October 24, 1996.⁸⁹ The agreement places legally binding obligations on members to take steps to ensure the establishment and implementation of general principles of nuclear power plant safety relating to the design, construction and operation of the plant.⁹⁰ But the Convention “does not require internationally uniform minimum safety standards” and is broadly open to interpretation.⁹¹ For example, parties must make all “reasonably practicable” improvements to upgrade safety and, if safety measures cannot be implemented, plants must be shut down “as soon as practically possible.”⁹² It is up to the individual states to determine what is reasonable and practical under these guidelines.⁹³

While these conventions, and the many safety committees that have been formed to assist countries in implementing the highest safety standards,⁹⁴ play an important role in establishing

⁸⁸ *Id.* at 992.

⁸⁹ *Id.* at 993.

⁹⁰ *Id.*

⁹¹ *Id.*

⁹² International Atomic Energy Agency, Convention on Nuclear Safety art. 6, July 5, 1994.

⁹³ Nocera, *supra* note 25, at 819.

⁹⁴ The IAEA, for example, has a Commission on Safety Standards, a standing body of senior government officials with national responsibility for establishing standards and other regulatory documents relevant to nuclear, radiation, transport, and waste safety. The Commission provides guidance on safety standards in order to ensure coherence and consistency between standards and provides general advice and guidance on safety standards issues. There are also several committees under the IAEA that serve a similar function of advising on the development and implementation of safety standards in the areas of nuclear installation, radiation, transport, and waste safety. International Atomic Energy Agency, Nuclear Safety & Security (June 2012), <http://www-ns.iaea.org/committees/>; The Nuclear Energy Agency has also formed The Committee on the Safety of Nuclear Installations, which works to assist member countries in maintaining and further developing the scientific and technical knowledge base required

and promulgating safety measures, they present recommendations only. There are not currently any mandatory safety protocols that a country must follow in designing, building, or operating a reactor. With the implementation of the recommendations left up to the individual nations, there is currently no way to ensure that the countries with nuclear power, and those developing it, are not putting other nations at risk. There is also a concern about older reactors. While these reactors can be retrofitted to meet new safety standards, they will never be as safe as the newer models. In the United States, for example, most of the 104 operating reactors are more than 30 years old. Steps must be taken to ensure that all nations are adhering to the highest standards of safety, including developing enforcement methods that will serve to incentivize countries to follow the rules.

e) *Challenges of Current Nuclear Energy Regulation*

While the international community has taken important steps to regulate the nuclear industry and safeguard against nuclear accidents, more must be done. While treaty regimes may be considered of limited value because they only bind parties to the treaty, and there are very few treaties of universal application, they are a recognized mechanism for binding parties and may be the best way to reach the greatest number of states.⁹⁵

One of the most important steps that must be taken is strengthening and enforcing mandatory safety standards. Traditionally, nuclear energy has been under the purview of domestic regulation, but “unilateral regulation is not necessarily the best way to protect the international environment.”⁹⁶ The international risks posed by nuclear power warrant common standards and safety practices among countries. In order to ensure the safest environment

to assess the safety of nuclear reactors and fuel cycle facilities. Nuclear Energy Agency, Committee on the Safety of Nuclear Installations (September 2012), <http://www.oecd-nea.org/nsd/csni/>.

⁹⁵ Michel Montjoie, *The Concept of Liability in the Absence of an Internationally Wrongful Act*, in THE LAW OF INTERNATIONAL RESPONSIBILITY, *supra* note 72, at 512.

⁹⁶ McMillan, *supra* note 17, at 988.

possible, the IAEA should institute mandatory standards that hold operators to the highest standards of safety in design, construction, operating protocols, training and supervision of employees, fuel storage and shipment and disposal requirements. Operators should also be required to upgrade existing facilities before they are allowed to continue operation. The IAEA's technical and scientific authority is universally acknowledged and the international community could look to that organization to set the necessary technical standards.⁹⁷ The IAEA must also give these safety requirements teeth by instituting civil or criminal penalties for countries that do not institute the standards. Obviously, this will place an enormous burden on countries, particularly those with limited resources or multiple plants, but the risks are too great to allow for any other solution. Without international standards of construction and design, a faulty plant build presents a completely unnecessary chance of disaster to the country and surrounding nations. Countries will have to work together to ensure that all plants meet these state-of-the-art standards in the interest of safety for all. No longer can compliance be left to the interpretation of individual nations.

The IAEA should also establish a specially trained team to respond in the case of a radioactive emergency. While it has taken the first steps with the Convention on Assistance in Case of a Nuclear Accident, this convention does not go far enough to ensure that a prepared team is ready in case of an emergency. The voluntary nature of assistance creates too much uncertainty about what expertise and resources would be available. By having a dedicated team, the IAEA can prepare them with specific training in radioactivity containment in order to offer the best possible outcome in case of a disaster. Teams could be established in different regions of the world in order to ensure a swift response should disaster strike. Some may view these

⁹⁷ Nocera, *supra* note 25, at 819.

precautions as burdensome, but they are a necessity given the damage that could result from a poorly managed nuclear accident.

While these changes would help to reduce the risk of a nuclear disaster, they cannot eliminate it. Current international laws and conventions also raise the question of whether stronger prohibitions against nuclear energy should be available. As things stand, it would seem that the laws of war, such as discrimination and neutrality, which outright prohibit the use of weapons and instrumentalities that threaten neutral territories, offer people and nations more protection than the environmental laws that only require efforts to mitigate potential damage. It is also worth noting that many of the laws surrounding the use of nuclear energy deal with the aftermath of a disaster, cold comfort for those populations that have been wiped out or for the survivors who must suffer the radiological effects for unknown generations. In order to offer comprehensive protection to a country against radiation, however, there would need to be a complete ban on nuclear energy. A country could agree with all the others around it not to allow nuclear energy and it would still be at risk if a plant were operating in the same hemisphere. There is no question that the ultimate prohibition of nuclear energy is the safest course, but it is not currently the most practical, nor is a ban on nuclear energy likely to gather the political support that would be necessary to enact it at this time. This is a worthwhile and admirable goal for the future, and continued efforts to develop nuclear weapons-free zones and to phase out nuclear energy in countries who wish to turn to alternative options will help to realize it, but steps must be taken now to ensure that the risk of a nuclear accident is minimized as much as possible in the face of the reality that for now, nuclear energy is a part of our world.

V. Reducing the Risk of Proliferation

The suggestions above are geared towards addressing the risks inherent in a nuclear accident, but that is not the only concern that nuclear energy raises. With regard to the risk of proliferation, the international community has suggested several approaches to try and minimize the risk for both theft of nuclear materials by terrorists and the possibility that a country will divert its materials from peaceful to military purposes. One of the key elements in the U.S. nuclear policy, as outlined in the Nuclear Posture Review, is “promoting the peaceful uses of nuclear energy without increasing proliferation risks” by “strengthening International Atomic Energy Agency safeguards and enforcing compliance with them,” but this does not address the problem of the spread of uranium enrichment and plutonium reprocessing.⁹⁸ The U.S. has also expressed support for one of the more popular suggestions for reducing proliferation, establishment of an international fuel bank or other methods of international control to help discourage countries from pursue indigenous fuel cycle facilities.⁹⁹

a) *Proposals for Increased International Oversight*

Several plans have been suggested that would establish some form of international, multilateral control over nuclear technology. On February 22, 2005, an expert group convened by the IAEA Director General released a five-step plan outlining how the international community might move toward international control of the production, reprocessing and disposal of nuclear fuel.¹⁰⁰ The plan suggested establishing internationally owned fuel cycle centers and an IAEA-administered fuel bank from which qualified parties could make withdrawals in the

⁹⁸ Department of Defense, Nuclear Posture Review Report, vi-vii (2010)

⁹⁹ *Id.* at 10.

¹⁰⁰ Spies, *supra* note 30, at 6.

event of disruptions in supply.¹⁰¹ All existing, nationally controlled, fuel cycle facilities would be voluntarily converted to multilateral control.¹⁰² New uranium enrichment and plutonium reprocessing facilities would also be subject to multinational control.¹⁰³ The plan focused generally on pushing for a more multinational arrangement of facilities and fuel production. No longer would each nation have its individual facilities. Instead, countries would develop stronger multilateral arrangements to accommodate the global expansion of nuclear power.

In 2006, Russia also proposed a plan to establish international fuel cycle centers, including development of an International Uranium Enrichment Center (“IUEC”) in eastern Siberia.¹⁰⁴ States participating in the IUEC would have access to fuel produced by the facility, but not the technology.¹⁰⁵ Russia also announced plans to establish a LEU reserve at the site.¹⁰⁶ To date, however, only a handful of countries have joined or expressed interest in the center, although it is open to all states without political preconditions.¹⁰⁷ This would seem to indicate reluctance by non-nuclear power states to participate in a program that would deny them access to nuclear energy technologies, while reserving that knowledge for a state that already has access to nuclear weapons. A similar reaction was seen to the American proposal.

On February 6, 2006, the Bush Administration announced the Global Nuclear Energy Partnership (“GNEP”). The program’s goal was to contain the spread of nuclear technology that could lead to proliferation.¹⁰⁸ The U.S. proposal would keep uranium enrichment and plutonium reprocessing in the hands of current technology holders, while providing fuel guarantees to those

¹⁰¹ *Id.*

¹⁰² Nikitin, *supra* note 1, at 18.

¹⁰³ Spies, *supra* note 30, at 6.

¹⁰⁴ Nikitin, *supra* note 1, at 20.

¹⁰⁵ *Id.*

¹⁰⁶ Spies, *supra* note 30, at 7.

¹⁰⁷ *Id.*

¹⁰⁸ *Id.* at 6.

who abandon the option. Under the GNEP, the world nuclear market would be divided into supplier states, who would be responsible for providing fuel services, including removal, reprocessing, and final disposal of spent fuel, and client states, who would have access to nuclear energy but would not operate their own fuel cycle facilities.¹⁰⁹ The plan specifically stated that participating states “would not give up any rights” to develop nuclear technology for peaceful purposes as guaranteed under the NPT.¹¹⁰ It is not clear, however, which states would be supplier states and which would be client states, or how that determination would be made.¹¹¹

The GNEP, now called the International Framework for Nuclear Energy Cooperation, or IFNEC, also envisioned the development of new technologies to eliminate the highly radiotoxic elements created by nuclear reactors. Some of these elements remain radioactive for hundreds of thousands of years and can also be used in nuclear weapons.¹¹² The Administration initially provided funding for the development of working facilities to demonstrate these technologies, but after heavy criticism from the House of Representatives, funding was cut in 2008 and the Department of Energy was directed to focus on research and development instead.¹¹³ Although a number of countries have joined the GNEP, many, including India, Israel, North Korea, Pakistan, and Iran, remain outside of its reach and are presently not bound by any of the developing rules restricting nuclear trade. Critics of this proposal have also suggested the concentrating spent fuel and high-level waste at a central storage location is not a safer option than the current policy of on-site storage.¹¹⁴

Most of these proposals, and others like them, are not new, but are variations of those

¹⁰⁹ *Id.*

¹¹⁰ *Id.*

¹¹¹ *Id.*

¹¹² *Id.*

¹¹³ *Id.*

¹¹⁴ Nikitin, *supra* note 1, at 29.

developed more than 30 years ago. Unlike then, however, the world currently faces a rapidly increasing need for power and, as fossil fuels fall out of favor, more and more countries are turning to nuclear, increasing interest in these programs and arguably increasing their chance of success. Some countries are concerned that their legal rights under the NPT to develop fuel cycle facilities would be infringed upon if multilateral facilities were established.¹¹⁵ Proponents have insisted that the arrangements are optional and meant to give countries an alternative to developing their own fuel cycle capabilities.¹¹⁶ If countries believe this, multilateral control facilities may gain favor. Non-nuclear weapons countries might also be incentivized to join these groups by the promise of the country supplying the fuel to remove the waste, so that the recipient country does not have to determine how to dispose of the radioactive materials.¹¹⁷ This would also allow countries supplying the fuel to better track these dangerous nuclear materials, which is safest for everyone involved. For some states, however, an external fuel assurance will always be inherently less reliable than a domestic supply.

While these initiatives may move forward with support of established nuclear supplier states such as Russia and the United States, the question remains whether the establishment of fuel assurance mechanisms will actually prevent proliferation. Ultimately, such assurances may have very little bearing on states determined to develop nuclear technology. There is also a question whether non-nuclear weapon states will accept additional restraints on their right to develop nuclear energy for peaceful purposes. These concerns aside, programs for multilateral control should push forward. If even one state is discouraged from establishing enrichment or reprocessing plants because of the availability of other options, the centers will have served to

¹¹⁵ *Id.* at 24-25.

¹¹⁶ *Id.* at 25.

¹¹⁷ ELLI LOUKA, *NUCLEAR WEAPONS, JUSTICE AND THE LAW* 268 (Edward Elgar Publishing, Inc., 2011).

reduce the risk of proliferation. There is also a chance that regional centers will become the norm to the point where a custom will be established in the international community opposing national development of these technologies. This is a chance worth pursuing.

b) Preventing Diversion and Terrorist Theft of Nuclear Materials

In order to acquire weapons-ready materials, terrorists would have to steal spent fuel, because fresh fuel rods contain no plutonium. Spent fuel is often stored in casks, sometimes underground, and is usually heavily guarded by security.¹¹⁸ Currently, even if terrorists were able to steal a spent fuel rod, they would still face the difficult task of separating the plutonium, which would require not only advanced technology and knowledge, but some form of shielding from the high radioactivity the materials produce.¹¹⁹ Additionally, commercial reactors use fuel rods for several years before they are replaced, which leads to many impurities, making it difficult to develop used fuel rods from commercial reactors into a weapon.¹²⁰ It is not inconceivable, however, that a terrorist could overcome these obstacles, and so the international community would be well-served to invest in the development of nuclear power generating technologies that are easier to safeguard or do not result in the creation of plutonium.

One solution that has been suggested is a new form of reactor known as the Integral Fast Reactor (“IFR”). Unlike other types of reactors, the IFR uses a different form of chemical processing and a different form of fuel rods so that the process never creates pure plutonium.¹²¹ Certain types of reactors are also easier to safeguard than others. Heavy water reactors, for example, are constantly fueled while they are in operation. In contrast, light water reactors must

¹¹⁸ Taylor Burke, *Nuclear Energy and Proliferation: Problems, Observations, and Proposals*, 12 B.U. J. SCI. & TECH. L. 1, 12 (2006).

¹¹⁹ *Id.* at 13.

¹²⁰ *Id.*

¹²¹ Robert Avery & Hans A. Bethe, *Breeder Reactors: The Next Generation*, in NUCLEAR POWER: BOTH SIDES, *supra* note 9, at 213.

be shut down before they are refueled. An operator who may wish to divert nuclear material to military purposes would have to shut down the reactor to remove the fuel, an easily observable activity.¹²² In addition, light water reactors are fueled with low-enriched uranium, which cannot be used for weapons. So one solution may be changing the type of reactors that countries are allowed to build by encouraging countries to share only the technology for these breeds of reactors.

Other solutions to deter theft include spiking the plutonium with radioactive substances and, somewhat obviously, tightening security at nuclear sites.¹²³ Anyone seeking to enter a plant would be checked out by security ahead of time and as people leave the plant, they must submit to a radiation check that reliably indicates whether they are carrying radioactive materials. Tracking measures might also be instituted for sensitive nuclear materials. With advancing technology, it may be possible to develop a system to help the owner of nuclear materials keep track of its location. This would be particularly important for operators that may be transporting nuclear materials between countries, either for energy or research and development needs, and could help the IAEA determine if materials have been diverted for non-peaceful purposes.

c) *A New Breed of Reactor*

There is a new class of reactor in the development stage, called the small modular reactor, which may serve to address a number of proliferation risks. These reactors produce a third of the megawatts, or less, of a typical reactor.¹²⁴ The entire reactor, or at least the vast majority of it, can be built in a factory and shipped to the site for assembly.¹²⁵ Several reactors

¹²² Louka, *supra* note 117, at 87.

¹²³ Michio Kaku, Ph.D. & Jennifer Trainer, *Where Do We Go From Here?*, in NUCLEAR POWER: BOTH SIDES, *supra* note 9, at 217.

¹²⁴ Ernest Moniz, *Why We Still Need Nuclear Power – Making Clean Energy Safe and Affordable*, 90 FOREIGN AFF. 83, 88 (2011).

¹²⁵ *Id.*

can be installed together to compose a larger nuclear power station if necessary. This type of reactor has advanced safety features and the design incorporates natural cooling features that can function even in the absence of power, making them much more secure than typical reactors.¹²⁶ Since these reactors are smaller, the construction costs are more manageable and the on-site construction time is shorter.¹²⁷ Factory construction means that a skilled work force can be developed, quality control mechanisms can be more easily enforced and there is a greater ability to continually improve the safety of the design.

Widespread acceptance of this new design would mean several things. Countries concerned about cost of a nuclear reactor would no longer need to build older generation reactors, but could use this new, less expensive model. Its smaller size and possible underground placement present less of a target for terrorists. Factory construction eases the way for implementation of universal safety standards. This new design would also prevent greedy or incompetent corporations from cutting corners in order to make a profit since its off-site construction and built-in safety measures would reduce the chances of design, build, or operator error. Finally, the ability to add units as power needs change means that countries will no longer have to build more reactor than they need. They can use this smaller unit, which poses a smaller risk of transboundary harm since less nuclear fuel is needed to produce energy. In conjunction with suggested solutions like multilateral control of uranium enrichment and plutonium reprocessing facilities, the risk of both catastrophic damage and proliferation of nuclear materials would be significantly reduced. Unfortunately, no small modular reactor design has yet been licensed by the NRC.¹²⁸ This should be a priority in the coming years.

¹²⁶ *Id.* at 88-89.

¹²⁷ *Id.* at 89.

¹²⁸ *Id.*

VI. The Necessity of Nuclear Power

It is critical to develop solutions to these risks and problems because, despite concerns about nuclear power, it is vital to addressing increasing energy needs worldwide. The rapid population growth of the last decades, and the advances in technology that have exponentially increased energy needs, have made nuclear power an attractive option for many countries.

a) *Alternatives to Nuclear Energy*

A country might consider fossil fuels to meet its energy needs, but there is increasing evidence that the global impact of these energy sources is greater than that of nuclear power, even if there were an accident that resulted in the spread of radiation.¹²⁹ Many critics of nuclear energy look to hydropower, wind and solar as replacements for nuclear energy. Renewable sources are expected to show the largest growth globally within the next twenty years.¹³⁰ Wind generation increased about 20% from 2008 to 2009 and has more than tripled since 2004.¹³¹ Currently, the U.S. generates about 13% of its electricity from renewable sources.¹³²

Most renewable energy power plants have less environmental impact than fossil or nuclear fuels, but they are often more expensive to build and operate. Coupled with the fact that renewable resources are often only available in remote areas, renewable energy is not used as much as it might be. However, in the U.S., federal tax credits and state-based Renewable Portfolio Standards, which require electricity providers to generate or acquire a certain portion of

¹²⁹ The OECD estimate of latent deaths from particulates in air pollution was 960,000 in 2000 alone, with about 30% of the pollution attributable to energy sources. Nuclear Energy Agency and Organisation for Economic Co-Operation and Development, *Comparing Nuclear Accident Risks with Those from Other Energy Sources* 47 (2010).

¹³⁰ Energy Information Administration, *Renewable Energy Explained* (2012), http://www.eia.gov/energyexplained/index.cfm?page=renewable_home.

¹³¹ *Id.*

¹³² *Id.*

their power supplies from renewable sources, have helped to encourage the use of renewable energies.¹³³

Some countries are leading the way in an attempt to prove that nuclear energy can be replaced by renewable options. In Germany, for example, 20% of the country's electricity comes from renewable sources, up from 6% in 2000, and the country has plans to reach 35% by 2020.¹³⁴ The government has encouraged this growth by providing significant financial incentives to the companies developing the technologies. The German government has plans to shutter all of its nuclear plants by 2022. It has also been suggested that the aging nuclear plant at Indian Point, less than 30 miles from New York City, might be replaced with alternative energy sources. In October 2012, the Natural Resources Defense Council issued a report outlining how investments in energy efficiency and renewable power sources could effectively replace the facility's power with no impact on the region's energy supply by 2020.¹³⁵

There are other benefits of alternative energies over nuclear. Uranium is a non-renewable resource, and although there is plenty of it stockpiled currently, some day it will run out. Wind and solar power do not face that problem. Although nuclear power plants do not emit carbon dioxide, sulfur dioxide, or other pollutants, fossil fuel emissions are associated with the uranium mining and enrichment process, as well as with the transport of uranium fuel to and from the nuclear plant.¹³⁶ Wind farms can also be constructed in about a year, as compared to several years for a nuclear plant, and do not require the extensive regulatory approvals associated with

¹³³ *Id.*

¹³⁴ *Germany's Having a Renewable Energy Goldrush*, October 18, 2011, <http://www.sustainablebusiness.com/index.cfm/go/news.display/id/23043>.

¹³⁵ Synapse Energy Economics, Inc., *Indian Point Replacement Analysis: A Clean Energy Roadmap* (October 11, 2012), <http://www.synapse-energy.com/Downloads/SynapseReport.2012-10.NRDC.Indian-Point-Replacement-Study.12-047.pdf>.

¹³⁶ U.S. Environmental Protection Agency, *Nuclear Energy* (October 17, 2012), <http://www.epa.gov/cleanenergy/energy-and-you/affect/nuclear.html>.

nuclear plant development.¹³⁷ Renewable energies would also provide countries with a locally produced energy supply and completely eliminate fuel costs at a global savings of billions of dollars a year.¹³⁸

Despite the multitude of benefits, there are drawbacks to renewable energy sources. Renewable energy is generally more expensive to produce and use than fossil fuels and nuclear energy. Renewable resources are often located in remote areas, and it is expensive to build power lines to cities where the electricity they produce is needed.¹³⁹ The use of renewable sources is also limited by the fact that they are not always available. Cloudy days reduce solar power; calm days reduce wind power; and droughts reduce the water available for hydropower. Although renewable resources have been growing at an extraordinary rate, renewable generators have average utilization rates well below those for other types of energy, and so despite the growth in the industry, particularly in wind power, the world still generated only 1% of its totally electricity from wind in 2009.¹⁴⁰ And while wind and solar power are becoming increasingly widespread, their intermittent and variable supply make them poorly suited for large-scale use in the absence of an affordable way to store electricity.¹⁴¹ There are also geographic concerns with renewable energies. For example, given the efficiency of wind turbines, which run at about 30% efficiency on average, you would need more than 9,500 of them to replace the output of the latest nuclear power plant model, which runs at approximately 90% efficiency.¹⁴² There are currently

¹³⁷ Greenpeace, Renewable Energy (February 2012), http://www.greenpeace.org/international/Global/international/publications/nuclear/2012/Fukushima/Fact%20Sheets/Renewable_Energy.pdf.

¹³⁸ *Id.*

¹³⁹ Energy Information Administration, Renewable Energy Explained (2012), http://www.eia.gov/energyexplained/index.cfm?page=renewable_home.

¹⁴⁰ *Id.*

¹⁴¹ Moniz, *supra* note 124, at 84.

¹⁴² James Conca, *The Naked Cost of Energy*, FORBES, June 15, 2012, at 1.

104 operating nuclear plants in the United States. A field of wind turbines large enough to meet the current nuclear output in the U.S. alone would measure tens of thousands of square miles.

In countries like Germany that have decided to phase out nuclear power, there will likely be an increased reliance on fossil fuels and energy imports from other nations in the coming years.¹⁴³ Germany has traditionally been a net exporter of energy thanks to its many nuclear facilities. As these shut down, and the country works to upgrade its current grid and develop new renewable energy sources, it may need to turn to countries such as France to meet its energy needs.¹⁴⁴ In all likelihood, the energy it imports will come from nuclear plants. These countries must also face the challenge of meeting climate change objectives while also replacing nuclear power. Germany, for example, has committed to cutting carbon dioxide emissions to 40% of 1990 levels by 2010, but it is currently in the process of building ten new coal-fired plants in order to fill the need for electricity caused by the shut down of nuclear power plants.¹⁴⁵

National decisions to phase out nuclear power may have some positive side effects. If the governments are serious about continuing to combat climate-change while also maintaining an anti-nuclear policy, the scientific community will experience unprecedented pressure to produce technological breakthroughs, such as commercially viable storage technologies and improved smart grid applications that could significantly benefit the international community. It is also arguable that no matter how difficult the transition to clean, renewable energy sources may be for these countries, it is nowhere near as complex as trying to keep nuclear reactors from melting down or proliferating nuclear weapons, or trying to find a safe way of disposing of highly radioactive wastes with a half-life of tens of thousands of years.

¹⁴³ Stephen J. Dubner, *What Happens Next as the World Turns Away From Nuclear Power?*, June 21, 2011, <http://www.freakonomics.com/2011/06/21/what-happens-next-as-the-world-turns-away-from-nuclear-power-a-freakonomics-quorum>.

¹⁴⁴ *Id.*

¹⁴⁵ *Id.*

While renewable energy sources present an attractive alternative to nuclear energy and could, potentially, be a replacement for the technology, the question is, when? At current growth and output rates, it will take decades for renewable options to completely replace nuclear technologies, particularly in light of increasing energy needs, both in the United States and internationally. Even if sufficient renewable sources were developed to replace nuclear energy, we still must contend with coal and gas-based energies that are poisoning the environment and causing global warming, a phenomenon that needs to be addressed sooner rather than later or there may be far greater consequences for our planet than a nuclear reactor disaster could ever cause. So, renewable sources must not only replace nuclear, but also fossil fuel technologies in order to be a viable future energy source, and they must do it soon in order to prevent global disaster, not from radiation, but from carbon emissions. Nuclear power is environmentally clean, produces no sulfur or carbon dioxide, and does not contribute to global warming. Embracing nuclear power is an opportunity to end our dependence on foreign oil before resources decrease to the point where our economy and infrastructure would be compromised. By developing our nuclear capabilities now, any uncertainty about energy sources could be avoided.

Perhaps the replacement of nuclear with renewable energies is possible in countries like the United States where a limited percentage of the energy comes from nuclear plants, but what about countries where nuclear provides 50% or 75% of the energy? Renewable energy would need to be developed at an incredible rate in order to offset nuclear energy output in those nations. There would need to be significant progress in the efficiency and development of these technologies, as well as a shift in worldwide energy consumption towards conservation before alternative energies could act as a possible replacement for nuclear. It is simply not a feasible proposition at this point. It would be far better to use nuclear to offset carbon technologies and

to invest in renewable energy development, including storage technologies, and then slowly phase out nuclear power as renewable technologies become more advanced. In an idealized world, this would happen simultaneously with nuclear weapons states fulfilling their disarmament obligations under the non-proliferation treaty so that eventually, both nuclear weapons and nuclear power will no longer exist. In order to ensure a truly nuclear weapons-free world, both will eventually have to go, otherwise, the risk of nuclear weapons will always be present as countries with enrichment and reprocessing technologies stand on the brink of having weapons once again.

b) A Nuclear Renaissance

As the demand for energy grows, countries continue to develop nuclear programs and many rely heavily on nuclear power. Today, 439 nuclear power reactors produce approximately 16% of the world's electricity.¹⁴⁶ In nine countries, over 40% of energy production comes from nuclear power.¹⁴⁷ Although reactor construction has been stalled in the United States for 25 years, the rest of the world has continued to build nuclear plants.¹⁴⁸ Current reactor construction is dominated by Asia where 44 of the 65 reactors under development worldwide are being built.¹⁴⁹ The renewed worldwide interest in nuclear power has led to a possible expansion of the technology to currently non-nuclear nations. Ten of the countries that are building or formally planning reactor projects have never operated nuclear power plants. This includes Belarus, Egypt, Indonesia, Jordan, Kazakhstan, Poland, Thailand, Turkey, the United Arab Emirates, and Vietnam.¹⁵⁰ Bangladesh, Chile, Israel, Malaysia, and Saudi Arabia may also be on the verge of

¹⁴⁶ United Nations, Global Issues, Atomic Energy (2012), <http://www.un.org/en/globalissues/atomicenergy/>.

¹⁴⁷ *Id.*

¹⁴⁸ Nikitin, *supra* note 1, at 6.

¹⁴⁹ *Id.*

¹⁵⁰ *Id.*

adopting nuclear power. The expansion of nuclear energy to these countries only highlights the importance of developing mandatory safety standards and proliferation-resistant technologies. If the world is serious about disarmament it must also be serious about significantly curtailing the spread of nuclear energy technologies, because the two are inextricably entwined.

VII. Conclusion

As the global need for energy continues to grow, more and more countries will seek to develop nuclear energy, including enrichment and reprocessing capabilities, citing state sovereignty and Article IV as justifications. While it is unlikely that countries will accept an interpretation of the NPT that completely blocks their access to certain nuclear technologies, systems can be put in place that will promote greater international control of dangerous materials and encourage countries to refrain from developing these technologies by guaranteeing fuel supplies. Ideally, one day clean, renewable energies will provide for worldwide energy needs, but that day has not yet come. For now, the focus must be on uniform international safety standards and development of technologies that minimize proliferation risks. The United States should embrace nuclear energy as a safe and clean alternative to fossil fuel technologies and be investing in the development of safer plant design and international structures that will reduce the risk of accidents and help to safeguard nuclear waste materials. Nuclear energy is not going away, so we must do all we can to ensure that every element of the nuclear fuel cycle is made as safe as possible.