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Author(s):	Joseph Pilat
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Nuclear Energy in a Nuclear-Weapon –Free World

Joseph F. Pilat, Los Alamos National Laboratory[1]

Introduction

The prospect of a nuclear renaissance has revived a decades-old debate over the proliferation and terrorism risks of the use of nuclear power. This debate in the last few years has taken on an added dimension with renewed attention to disarmament. Increasingly, concerns that proliferation risks may reduce the prospects for realizing the vision of a nuclear-weapon-free world are being voiced. We have not witnessed as comprehensive a discussion since the early efforts to grapple with the emerging atomic age in the mid- to late-1940s.

At that time, the dual (military-civil) nature of the atom was recognized. The Acheson-Lilienthal report envisioned a world without nuclear weapons; one in which nuclear power for peaceful purposes might thrive. The authors of the report were hopeful about the future of nuclear power, but concerned about the possible misuse of civilian nuclear power programs for military purposes.[2] The report "recognized that the industry required and the technology developed for the realization of atomic weapons are the same industry and the same technology which play so essential a part in man's almost universal striving to improve his standard of living and his control of nature."[3] More specifically, it

[1] The views expressed are the author's own and not those of the Los Alamos National Laboratory, the National Nuclear Security Administration, the Department of Energy or any other agency.
[2] See *A Report on the International Control of Atomic Energy, Prepared for the Secretary of State's Committee on Atomic Energy* (Washington, D.C.: U.S. Government Printing Office, March 16, 1946); and Statement of United States Policy, presented to the United Nations Atomic Energy Commission by US Representative Bernard Baruch, June 14, 1946.
[3] *A Report on the International Control of Atomic Energy,* p. 2.

declared: "The development of atomic energy for peaceful purposes and the development of atomic energy for bombs are in much of their course interchangeable and interdependent."[4]

This reality posed a dilemma: How could the atom be used for peaceful purposes in a world with no nuclear weapons--without undue risk? A proposal designed to achieve the international control of atomic energy was devised. The Baruch plan, based on the Acheson Lilienthal report, was presented to the United Nations Atomic Energy Commission (UNAEC) on June 14, 1946. Baruch stated that: "We must provide the mechanism to assure that atomic energy is used for peaceful purposes and preclude its use in war. To that end, we must provide immediate, swift, and sure punishment of those who violate the agreements that are reached by the nations. Penalization is essential if peace is to be more than a feverish interlude between wars. And, too, the United Nations can prescribe individual responsibility and punishment on the principles applied at Nuremberg by the Union of Soviet Socialist Republics, the United Kingdom, France and the United States - a formula certain to benefit the world's future."[5]

The Baruch plan has often been criticized for this focus on punishing noncompliance, but this was seen as essential if the United States was to surrender its nuclear weapons. The plan proposed:

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[4] Ibid., p. 4.
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...the creation of an International Atomic Development Authority, to which should be entrusted all phases of the development and use of atomic energy, starting with the raw material and including:

1. Managerial control or ownership of all atomic-energy, activities potentially dangerous to world security.
2. Power to control, inspect, and license all other atomic activities.
3. The duty of fostering the beneficial uses of atomic energy.
4. Research and development responsibilities of an affirmative character intended to put the Authority in the forefront of atomic knowledge and thus to enable it to comprehend, and therefore to detect, misuse of atomic energy. To be effective, the Authority must itself be the world's leader in the field of atomic knowledge and development and thus supplement its legal authority with the great power inherent in possession of leadership in knowledge.

Amid the emerging Cold War and Soviet suspicion of US motives, the proposal languished in the UNAEC as the Soviet Union and the United Kingdom developed nuclear weapons themselves. The Baruch plan was not realized and the issue of disarmament was no longer on the table in the same way when the "Atoms-for-Peace proposal" appeared.

On December 8, 1953, President Dwight D. Eisenhower, in a historic speech to the United Nations General Assembly, announced a proposal that would redefine the principles of nuclear policy in the early years of the nuclear age. The president sought to

expedite the development of the peaceful uses of nuclear energy. By offering the benefits of peaceful nuclear technology to those states that renounced nuclear weapons, he also sought to promote nonproliferation. The proposal was an arms control measure as well, as it foresaw the United States and other nuclear-weapon states providing excess nuclear material to an international authority that would use it for peaceful rather than military purposes.

The Atoms-for-Peace proposal and the international nuclear nonproliferation regime that emerged from its bargain were based on the atom's dual nature. In the address to the United Nations presenting his Atoms for Peace proposal, President Eisenhower declared:

> The governments principally involved, to the extent permitted by elementary prudence, should begin now and continue to make joint contributions from their [military] stockpiles of normal uranium and fissionable materials to an international atomic energy agency. We would expect that such an agency would be set up under the aegis of the United Nations....
>
> The atomic energy agency could be made responsible for the impounding, storage and protection of the contributed fissionable and other materials. The ingenuity of our scientists will provide special safe conditions under which such a bank of fissionable material can be made essentially immune to surprise seizure.[6]

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[6] For details on these programs, Atomic Power for Peace, an address by Dwight D. Eisenhower, President of the United States, before the General Assembly of the United Nations, December 8, 1953; and Joseph Pilat, editor, *Atoms for Peace: A Future after Fifty Years?* (Baltimore, MD: Johns Hopkins University Press, 2007).

This swords-to-plowshares vision of the nuclear future was less dramatic than the failed Baruch Plan, and it was no longer tied directly to disarmament (despite its intention to allow nuclear arms reductions). Its wide acceptance and influence did not end concerns about the very dual nature of the atom that made the proposal possible. For decades, those who believed we could manage the risks of nuclear power have recognized its inherent dangers, but pointed to the dedicated military programs of most proliferants as the real source of concern. Those who were less sanguine about the prospect of harnessing a promising but dangerous technology in a world rife with conflict often argued against the use of nuclear power altogether, or at least opposed closing the nuclear fuel cycle.

The Nuclear Energy Debate

The post-Atoms for Peace nuclear energy debate in the United States and globally, which did not address disarmament, has waxed and waned, depending upon real-world developments such as the concerns derived from extrapolations of rapid, even exponential, growth in nuclear power and by the actual emergence of proliferation threats, notably the Indian program in the 1970s, the Pakistani program in the 1980s and the Iraqi, Iranian, North Korean and Syrian programs in the 1990s and this decade. The accidents at Three Mile Island and even more so Chernobyl have also greatly affected the debate.

In recent years, the debate has been reengaged on a level not seen since the 1970s. There are similarities between the debate now and 30 years ago, for example:

- expectations of dramatic growth in nuclear power;
- concerns about reprocessing and plutonium use; and

- perceptions of rising proliferation and terrorism threats.

But there are major differences. On the one hand, today proliferation dangers appear more real or concrete, if not necessarily greater than they did thirty years ago when attention focused on plutonium. The risks from highly enriched uranium (HEU) are now seen as greater.[7] The risks are also increasingly seen to be emerging from unanticipated sources, including nonstate actors. The prospect of nuclear terrorism is receiving unprecedented attention (although it was a factor in the debate during the 1970s). After 9/11, some concluded the danger of any use of nuclear power was too great to accept.[8]

On the other hand, the desire for energy independence has led to increased interest in nuclear energy. And global warming concerns have convinced many, including some staunch environmentalists, of the need to pursue nuclear power aggressively.[9] Moreover, to address rising concerns about proliferation and terrorism, strong efforts to reduce nuclear power's risks and vulnerabilities are being proposed and undertaken, including efforts to avoid separation of plutonium in the future. Nuclear energy and nonproliferation proposals by former IAEA Director General Mohamed ElBaredei, former US President George W. Bush and others have been seen in the context of this long-standing debate. The renewed interest in disarmament generated by the proposals of the so-called "Four Statesmen" and the policies

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[7] This perception is largely based on the spread of centrifuge enrichment technology by the A.Q. Khan network and, to the extent it may represent an overreaction, may be reconsidered in the future.

[8] See, e.g., Ralph Nader, "Nuclear Power is not the Answer," 11 September 2007 at <http://www.commondreams.org/archive/2007/09/11/3761/>

[9] See, e.g., Patrick Moore, "Nuclear power: Massachusetts is facing up to Carbon Choices," *Patriot Ledger*, 12 April 2008 at http://www.patriotledger.com/opinions/x1403477302; and James Lovelock, "Nuclear Power is the only Green Solution," *The Independent*, 24 May 2004 at < http://www.ecolo.org/media/articles/articles.in.english/love-indep-24-05-04.htm>

of President Barack Obama has taken the debate back beyond the 1970s and even Atoms for Peace and has returned us to the beginning—the '40s.n The impact has been the growing recognition that nuclear energy's risk have the potential to undermine the disarmament project, and calls to pay greater attention to addressing these risks at a time they are changing.

Proliferation and Terrorism threats and Responses Today

In the context of rising regional instability and conflict, along with increased incidents of global terrorism, in a dynamic, uncertain security environment, emerging nuclear and other weapons of mass destruction (WMD) threats—both proliferation and terrorism—are seen as growing dangers giving rise to increasing global insecurity. Many observers believe today that additional states as well as nonstate actors will obtain a nuclear-weapon capability or nuclear weapons, and that these weapons are more likely be used than in the past. Although the notion of nuclear anarchy or a "nuclear armed crowd"[10] may represent the worst-case scenario—which is by no means the inevitable or even the most likely future—it is clear that the threat situation today is serious.

Efforts to reduce, mitigate or eliminate these risks—at least those we anticipated—are decades old. They have involved deterrence and its extension to allies from the beginning. But they have primarily focused on the international nuclear nonproliferation regime. Regime-based responses to the threat in the nuclear realm, including the International Atomic Energy Agency (IAEA) and the Treaty on the Nonproliferation of Nuclear Weapons (NPT).

[10] See Albert Wohlstetter et al., *Moving Toward Life in a Nuclear Armed Crowd?* Report to the US Arms Control and Disarmament Agency (Los Angeles: Pan Heuristics, 1976).

The global treaty and institution approach has been important for setting norms concerning nuclear and other weapons of mass destruction and missiles, and the treaties have been influential in redefining thinking about the problem. However, the NPT and the international nuclear non-proliferation regime were created in a different time to deal with a different set of threats.

Will the regime be able to address the challenges of today, along with those that will emerge with an expansion of nuclear energy around the world? There are divergent views on whether the regime will be able to meet the challenges ahead.[11] However, in the face of these challenges, the regime is evolving as threats have changed, as is evident in the case of safeguards.

In the last decade and a half, the International Atomic Energy Agency has been transforming its safeguards system to address, in part, the limits of its verification mandate and the burden of noncompliance issues, which have raised questions about the value and effectiveness of international safeguards. In this context, the IAEA is adopting a fundamentally new approach to implementing safeguards based on the strengthening measures developed in the 1990s and the lessons learned from Iraq, North Korea, Libya and Iran. It is recognized that an effective, strengthened international safeguards system, with a strong focus on searching for undeclared nuclear materials and activities, is essential to provide confidence that shared nuclear

[11] For a wide-ranging debate over the fate of the international nuclear order and the NPT regime, see the essays in *International Affairs*, vol. 83, no. 3 (May 2007).

technologies and expertise, as well as nuclear materials themselves, are not being diverted to nuclear-weapon programs.

Central to the transformation is the Additional Protocol (AP), which is an important new tool and needs to be universally accepted as the basis for safeguards and a condition for exports. Although most states with significant nuclear activities have now brought the AP into force, there remain a large number of states that have not yet ratified the Additional Protocol. The Agency and member states are trying to remedy this situation, and to address the problem of the universality of comprehensive safeguards agreements as well.

Implementing the new measures in the Additional Protocol, as well integrating traditional and new safeguards authorities, remains a work in progress. Fundamental to the new approach to IAEA safeguards is information acquisition, evaluation and analysis along with inspections. The new approach is designed to provide an evaluation of the nuclear program of a state as a whole—including possible clandestine facilities and activities—and not just each of its declared nuclear facilities. If they are to meet the demands of global growth in nuclear energy use, it is essential that safeguards be credible and efficient.

In addition to strengthening safeguards and other traditional regime elements such as export controls, initiatives to address new and emerging threats, and unanticipated developments—from the end of the cold war to the rise of terrorism—have been especially prominent in the last 15-20 years. Among these are critical initiatives involving threat reduction, detection and interdiction, such as programs for Cooperative Threat Reduction, Material Protection,

Control and Accounting and Second Line of Defense, including the Megaports Initiative; the Proliferation Security Initiative and the Global Threat Reduction Initiative; the Global Initiative for Proliferation Prevention and the Global Initiative to Combat Nuclear Terrorism; and UNSC Resolution 1540, the Convention on the Suppression of Nuclear Terrorism and the amendments to the Convention on the Physical Protection of Nuclear Material.

Beyond these and other programs and initiatives, there are several ideas that are being considered, or rather reconsidered today to address proliferation and terrorism risks. Offering an assured supply of fresh nuclear fuel and spent-fuel take back are old ideas that are receiving new attention. Along with fuel banks, such initiatives have become central to thinking about addressing emerging challenges. Proposals by former International Atomic Energy Agency Director General Mohammed ElBaradei and others on multinational or multilateral ownership have roots in the Acheson-Lilienthal report and Baruch Plan and can also be seen in this context.[12]

The difficulties of realizing these or any of the other proposals that have been put forward to minimize proliferation risks through reliable supply are significant and have bedeviled past efforts along these lines. Although such approaches have failed before, there are key differences in the situation today from that of the earlier considerations of such proposals, including a more widespread sense of insecurity; the rise of new, illegitimate sources of supply, including black marketers; evidence of NPT noncompliance; and the prospect of

[12] See, Mohamed ElBaradei, "Toward a Safer World," *The Economist*, 18 October 2003. See also the report of experts that followed up the original ElBaradei proposal, *Multilateral approaches to the Fuel Cycle*, Expert Group Report submitted to the Director General of the International Atomic Energy Agency, issued as INFCIRC/640 at <www.iaea.org>

nuclear terrorism. On the other hand, there remain suspicions that such proposals are designed to undercut Article IV rights. In any event, the viability of current proposals depends ultimately on common interests (commercial, political, industrial, etc.). They cannot be imposed from the top down or on any states, nor should they interfere with market mechanisms or access to the benefits of the peaceful uses of nuclear energy.

Finally, new attention to another old idea—proliferation resistance—has grown and can be expected to grow in the years ahead. Proliferation resistance was first raised in the Acheson-Lilienthal report's discussion of "denaturing." According to the report:

> ...U 235 and plutonium can be denatured; such denatured materials do not readily lend themselves to the making of atomic explosives, but they can still be used with no essential loss of effectiveness for the peaceful applications of atomic energy. They can be used in reactors for the generation of power or in reactors useful in research and in the production of radioactive tracers. It is important to understand the sense in which denaturing renders material safer. In the first place, it will make the material unusable by any methods we now know for effective atomic explosives unless steps are taken to remove the denaturants. In the second place, the development of more ingenious methods in the field of atomic explosives which make this material effectively useable is not only dubious, but is certainly not possible without a very major scientific and technical effort.[13]

The report recognized that denaturing could be reversed, but held that "doing so calls for rather complex installations which, though not of the scale of those at Oak Ridge or Hanford,

[13] *A Report on the International Control of Atomic Energy,* pp. 26-27.

nevertheless will require a large effort and, above all, scientific and engineering skill of an appreciable order for their development."[14]

The authors of the report were overly hopeful of denaturing, and the pursuit of a technological way to make the peaceful uses of nuclear energy resistant to proliferation appears and reappears in the history of nuclear power. The concept of proliferation resistance has never been well defined and has usually been oversold. It does not and cannot mean "proliferation-proof." However, there are benefits that may yet be realized from reactors and other facilities designed to minimize proliferation risks coupled with effective safeguards and other nonproliferation measures. The idea of proliferation-resistant small reactors with long-lived cores is among the new ideas for addressing underlying proliferation concerns, while expanding nuclear power to the developing world and increasing the attractiveness and acceptability of nonproliferation efforts. In this as in other cases, if proliferation resistance is to be real, it must be institutionally as well as technically based. There are no simple technological fixes or "silver bullets."

All of these responses to current and emerging threats have been embroiled in controversy to some degree. They are important, however, as efforts to reinforce and reform the global nonproliferation regime to address emerging proliferation and terrorism risks. But not all are agreed or fully developed and implemented; and, if accepted, they may not be enough to address future threats.

[14] Ibid., p. 27.

Responding to Tomorrow's Threats

Beyond the responses of today and their realization, what do we need to ensure we can respond to tomorrow's threats? How can we do this in a way that facilitates disarmament?

Our record of anticipating threats has not been great. There is a need for improved capabilities in this regard. Even with the best threat assessment capabilities, however, we will likely still be surprised. The threat is dynamic and we must have the tools critical to respond effectively and rapidly to any new threats, and create conditions that will increase the prospects for disarmament.

Beyond today's threats, the conditions under which one could envision widespread proliferation in the longer term depend on such factors as the dramatic growth of nuclear power, broader technology diffusion, globalization, regional and international security environments and the like. Of these factors, which are all difficult to predict with any certainty, there are proliferation challenges we can anticipate today based on technology spread and on the development of certain technologies for civil use. The threats stemming from the spread of technology include:

- technology diffusion via the Internet as well as through loose nukes, materials leakage and brain drain in the former Soviet Union, Pakistan and other states and through non-state actors like the A. Q. Khan network; and

- the security of nuclear and related technologies, materials and expertise in Russia and the other Soviet successor states, as well as in such states as South Africa, Argentina and Brazil.

Challenges based on technologies that are coming into use, or are expected to do so, include the following:

- large, increasingly complex new facilities, with high material throughputs where improvements in current technology alone cannot meet detection goals;
- difficult-to-measure materials and harsh environments with high dose rates, temperatures, etc.;
- the need to measure new isotopes and combinations of isotopes with, for example, separations outputs of pyroprocessing and electrorefining;
- the need to measure both continuous flows of nuclear materials and of non-nuclear process parameters (temperature, density, flow rate, etc.); and
- possible diversions without physical change to plant through process controls, chemistry, etc.

History shows there will be many proliferation challenges we do not anticipate, including clandestine facilities, breakouts after abrogating treaty obligations, the emergence of new technologies and the like.

To address all of these challenges—both anticipated and unanticipated—one promising approach involves the further development of a defense-in-depth safeguards and security

approach that can be more responsive to emerging threats. Elements of such an approach would include, inter alia:

- state-of-the-art instrumentation and methodologies for materials detection, measurement, accounting and tracking, including sensor platform integration;
- enhanced containment and surveillance, including portal and area radiation monitoring;
- integration of access denial and transparency elements of physical protection and safeguards; and
- integration of traditional process monitoring with non-traditional indicators, such as detection of radiation signals at unexpected locations, suspicious movements of equipment and people, etc.

To realize such a system, and to address other needs, there is a real need to reinvigorate robust R&D programs,[15] including novel technologies and techniques to:

- model facility safeguards design to assess detection paths and sensitivity to detection;
- integrate facility design to enable advanced safeguards and physical security, and to optimize proliferation resistance;
- detect undeclared facilities and activities; and
- enhance nuclear forensics and attribution.

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[15] An American Physical Society report concluded that US investments in safeguards R&D had declined precipitously and needed to be revived if we were to be able to meet future challenges. See, e.g., *Nuclear Power and Proliferation Resistance*, A report by the Nuclear Energy Study Group of the Panel on Public Affairs. American Physical Society, May 2005, at <www.aps.org/public_affairs/proliferation-resistance/>

Finally, there is also a need to utilize systems analysis to evaluate design tradeoffs as well as to assess the effectiveness of an integrated system as a whole.

The pursuit of such capabilities will affect and presumably be influenced by, the goal of diasarmament. If proliferation and terrorism risks are not effectively addressed, it is increasingly believed that the prospects for disarmament will decrease. This has been the focus of the debate, but there is also a need to better understand other aspects of relations between nuclear energy to disarmament, including whether civil nuclear facilities can provide a "hedge" to states pursuing disarmament and the impact of multinationalization approaches in this context.

Conclusions

The prospects for disarmament were at the forefront of the debate on nuclear power in the 1940s and early'50s. This issue did not play the same role during the Cold War as nuclear disarmament appeared distant and civilian nuclear power thrived and then declined in many areas around the world. Disarmament was always at the heart of the NPT review process, but did not return to the fore of the nuclear energy debate until the last few years.

The reintroduction of disarmament into the debate has reinforced the need to strengthen nonproliferation efforts, raised the stakes of success and remind us of the mutual interactions and interdependence of the three pillars of the NPT. A nuclear-weapon-free world and the benefits of nuclear power will require measures to reduce risks of proliferation and terrorism that are more effective and efficient than those in use today.

Enhanced verification and a consensus on addressing noncompliance will be critical. Safeguards need to continue to evolve. Technologies must be advanced. Existing safeguards authorities need to be exercised fully and new authorities will be needed. Export controls will need to be tightened and nuclear security enhanced.

Proliferation resistance has a limited but important role to play, in particular by facilitating safeguards implementation, the safe and secure management of plutonium, the reduction of civil uses of HEU and the disposition of excess defense stocks. Reliable supply at the front- and back-ends of the fuel cycle may be needed. Multinational/multilateral ownership needs to be explored in this context.

Such efforts, and no doubt others that may be proposed, are likely to be engulfed in the ongoing debate and are by no means assured of success. If realized, however, they have the potential to assure that nuclear power growth does not increase proliferation and terrorism risks, but instead creates a framework for addressing these risks in the context of moves toward disarmament. To achieve the goal of disarmament is, realistically, a long-term project, as President Obama stated in Prague. It will depend on laying a number of foundation stones, one of which is the evolution of the NPT regime into a more "watertight" nonproliferation regime, even in the midst of an expected nuclear renaissance.