FAS Issue Brief July 2014

Advancing U.S. Leadership in Nonproliferation and Nuclear Energy through Effective Partnerships

Charles D. Ferguson

Federation of American Scientists

FAS ISSUE BRIEF

Author

Charles D. Ferguson, Ph.D., is the President of the Federation of American Scientists (FAS). Prior to joining FAS, Dr. Ferguson served as the project director of the Independent Task Force on U.S. Nuclear Weapons Policy, chaired by William J. Perry and Brent Scowcroft, at the Council on Foreign Relations (CFR). Previously, from 2002 to 2004, Dr. Ferguson had been with the Monterey Institute's Center for Nonproliferation Studies (CNS) as its scientist-in-residence. At CNS, he co-authored the book The Four Faces of Nuclear Terrorism and was also lead author of the award-winning report "Commercial Radioactive Sources: Surveying the Security Risks," which was published in January 2003 and was one of the first post-9/11 reports to assess the radiological dispersal device, or "dirty bomb," threat. From 2000 to 2002, he served as a physical scientist in the Office of the Senior Coordinator for Nuclear Safety at the U.S. Department of State, where he helped develop U.S. government policies on nuclear safety and security issues.

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Cover Image

The cover image is a photograph taken by the author during a visit to the Vogtle Nuclear Power Plant in Georgia in 2013. Vogtle represents an outstanding example of international partnership for the United States because the Republic of Korea and Japan have supplied major components to the two reactors now being constructed at the plant. The photo shows the cooling towers for the two existing and operating reactors.

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Rationale for this Report

This report responds to renewed concerns that the United States has lost its leadership in nonproliferation and nuclear energy development.[1] Although the United States still has the largest number of nuclear power plants in the world, it does not dominate global nuclear power. Moreover, while the United States was the leading nuclear power supplying nation more than thirty years ago—at least for states outside of the Soviet sphere of influence—the reality today is clearly that the U.S. nuclear industry is only one of several major suppliers. The United States can no longer build a large nuclear power plant on its own. Foreign nuclear companies own major U.S. nuclear power companies.

In addition, the United States no longer supplies the majority of the world's enriched uranium for nuclear fuel; instead, the United States Enrichment Corporation has shut down its enrichment plants based on gaseous diffusion and has been struggling to commercialize the American Centrifuge Project partly due to reduced global demand for enriched uranium and also due to competition from established enrichment companies. The only enriched uranium being produced on U.S. territory is in New Mexico, as Urenco (a European consortium corporation) is building an enrichment plant there. Urenco is based mostly in Germany, the Netherlands, and the United Kingdom, which are the founding countries of this consortium. France and Russia contain the other major uranium enrichment plants. Combined, the French, Russian, and Urenco suppliers provide more than 90 percent of the globe's enrichment capacity at competitive prices. In terms of the ability to enrich uranium, the United States has undoubtedly slipped far from being number one in the world.

Nonetheless, the United States continues to have great influence on the nuclear market because many of the major supplying nations have built their nuclear power programs on the basis of U.S. technology. U.S.-origin nuclear companies such as Westinghouse and General Electric (which have been bought by Japanese companies Toshiba and Hitachi) still are leaders in designing new reactors that are evolutionary improvements on the previous generation of reactors. Hand-in-hand with the concerns about U.S. leadership in nuclear commerce is whether the United States has lost or is losing leadership in nuclear nonproliferation. After all, the U.S. government was a major architect, if not the key creator, of the international system to stem further proliferation of nuclear weapons. Due to the inherent dual use nature of nuclear fuel making technologies, this system had to place adequate controls on peaceful nuclear programs to guard against their misuse in nuclear weapons programs.

In this report, I examine options for gaining back U.S. leadership in nonproliferation through a cooperative approach and assess what nations appear to be effective partners for the United States in furthering nonproliferation while providing for continued use of peaceful nuclear energy. I start from the premise that the nuclear industry is increasingly globalized, and thus the United States must partner with allies and other nations to advance its nonproliferation objectives.

I use criteria that include: (1) the applications of advanced safeguards such as the Additional Protocol to Comprehensive Safeguards Agreements as well as the enactment of national laws and statements of political leaders in various partner and potential partner nations, (2) the support of

[1] See, for example, The CSIS Commission on Nuclear Energy Policy in the United States, *Restoring U.S. Leadership in Nuclear Energy: A National Security Imperative*, A Report of the CSIS Nuclear Energy Program, Center for Strategic and International Studies, June 2013.

these nations to the international nonproliferation system such as the International Atomic Energy Agency and the Nuclear Suppliers Group, (3) the proliferation-resistance of technologies that these nations have developed or are wanting to develop, for example, if a nation is exploring recycling of plutonium, the United States has to consider whether the nation is investigating or investing in technologies that completely separate plutonium or keeps this fissile material mixed with other materials to potentially increase its proliferation-resistance, (4) the physical protection measures that a nation applies to its nuclear materials and facilities, (5) the efforts and commitments a nation makes to nuclear security, for example, the support for the Nuclear Security Summit process and whether a nation has created or has participated in a Center of Excellence for Nuclear Security or has taken extra means to improve the security of fissile materials and nuclear facilities, (6) the work done with client nations to promote high standards of nonproliferation and security, and (7) the effectiveness of export control laws and regulations. I chose these criteria because considered in their totality they form a strong nonproliferation system. My view is that there is not purely an objective approach available for ranking partners; there will always be some subjectivity in determining who are effective partners for advancing nonproliferation and peaceful nuclear energy. Still, I believe that the criteria outlined and the analysis in this report provides a guide for decision-making. This report does not rank each partner or potential partner with a numerical score but instead provides a narrative description of what various nations have been doing or not doing in the framework of the criteria. The approach in this report could encourage, by showing outstanding examples, what is needed to improve nonproliferation and nuclear security.

Nuclear Safeguards: The Evolution to More Effectiveness

Safeguards on nuclear programs are not foolproof; a determined nation that wants to misuse peaceful nuclear technologies can do so to make fissile material for nuclear weapons. From the very beginning of the nuclear age, the Acheson-Lilienthal report, published in early 1946 by the U.S. government, warned that no national system of controls on what was then called "atomic" technologies would provide adequate protection against proliferation of nuclear weapons. That report recommended the development of an international control system in which nations would turn over their atomic technologies and materials to an Atomic Development Authority. That system would not be perfect, but it would, argued the authors, give better warning of the onset of atomic weapons programs. While an account of why this system was not implemented by the United Nations is beyond the scope of this present report, many U.S. officials and nonproliferation experts have sought the need for developing effective controls before these technologies spread to more and more nations.

Nations have had various options for controlling nuclear power for peaceful or military purposes. One option, as outlined above, was to not have any nation have complete control of nuclear technologies but to create an international entity that would have tight control, including over nuclear materials. This was not to be because certain nations did not want to surrender their professed sovereign right to develop national nuclear programs. Another option during the start of the atomic age was for the United States to exert monopoly control as long as possible; it was the first nation to develop atomic bombs and had the first major nuclear infrastructure. But this was not to be because both allied nations such as Great Britain and enemy nations such as the Soviet Union were determined to move ahead with their nuclear programs. More importantly, the "secret" was

already out. Once the Manhattan Project had shown that enrichment and reprocessing technologies can produce the nuclear weapons' materials of highly enriched uranium and plutonium, any nation willing to devote adequate financial, technical, and human resources can also, with enough development time, make these materials and proceed to build nuclear weapons. However, the United States did attempt with the 1946 Atomic Energy Act to keep nuclear technologies secret and controlled. Even Great Britain, arguably the closest ally to the United States, was barred from having access to U.S. nuclear information despite the fact that many British scientists had worked on the Manhattan Project. That all changed with the 1954 Atomic Energy Act, which grew from President Dwight Eisenhower's December 8, 1953 "Atoms for Peace" speech.

While a detailed examination of the Atoms for Peace Program is beyond the scope of this report, I point out some salient issues regarding openness of information and technologies, cooperation and competition, and the steps toward an international system of inspections and control.[2] Eisenhower saw an opportunity to have the United States seize the initiative during the Cold War by offering its nuclear technologies and its nuclear scientists and engineers to help the world apply these technologies for peaceful purposes. To do so, the United States needed to change its laws in order to specify the conditions for sharing of nuclear information and technologies. It did that with the enactment of the Atomic Energy Act of 1954. Soon after Eisenhower's speech and the enactment of this act, the United States sponsored a major conference in which dozens of nations gained access to much of the knowledge needed to make nuclear power programs. In particular, reprocessing technologies were declassified, and several countries expressed interest in reprocessing because the view in the 1950s was that natural uranium was scarce and that plutonium-based nuclear fuels would be needed to power the large number of nuclear plants that many nations stated they would build. In addition to the spreading of reprocessing knowledge, the United States distributed dozens of research reactors to its client states, which were generally political or military allies of the United States. These reactors were usually fueled with highly enriched uranium. Within a couple of decades after the start of the Atoms for Peace Program, the United States and the Soviet Union began a program to reduce the enrichment in these reactors and take back HEU supplied to their client states.

Competition for client states was and still is a major motivator for the United States. If the United States could remain the major supplier for reactors, fuel, and other services, it could dominate the market. That was the position of the United States among client states outside the Soviet sphere of influence until about the late 1970s, when European suppliers of enrichment services as well as reactors began to seriously challenge the United States. While the United States tried to exert dominance in the nuclear market, it still had to rely on cooperation among allies and other client states. A pillar of nuclear energy cooperation is to ensure that a peaceful nuclear program remains peaceful.

Although nations were not willing to give total control to an international agency, they were willing to create the International Atomic Energy Agency (IAEA) in 1957. The agency has a dual role of promoting peaceful nuclear energy and related technologies as well as monitoring such programs to sound the alarm about potential nuclear weapons development. However, the IAEA, as an international agency, only has as much political authority as member states will give it. From the beginning, many member states were reluctant to provide the IAEA with rigorous intrusive

[2] For a book length analysis of the Atoms for Peace Program, see Joseph F. Pilat, editor, *Atoms for Peace: A Future after Fifty Years?* (Baltimore, Maryland: The Johns Hopkins University Press, 2007).

capabilities to investigate nuclear programs. As this report shows, it took shocks to this international nuclear system to force states to move toward more effective safeguards.

Safeguards have evolved from limited bilateral agreements specifying monitoring only particular parts of a nuclear program to comprehensive agreements covering all nuclear materials, facilities, and activities in a state. Safeguards, by themselves, will not prevent proliferation; if effective, they will sound a figurative alarm of a potential or actual violation and give states adequate time to respond to take action about the suspected violation. Doubts are still raised about whether the current safeguards system can provide such a timely warning.[3] While I also share these concerns, this report describes practices that have been developed and implemented that could point the way toward even better safeguards in the future.

During the 1960s, safeguards were typically only applied to reactors and reprocessing plants but not on enrichment facilities. The prevailing belief was that enrichment facilities were hard to build and thus would not quickly spread to other nations. But by the early 1970s, the Urenco consortium was operating in Europe using gaseous centrifuge technology. Soon afterwards, an employee of Urenco named A. Q. Khan stole design documents, left the company and returned to his native Pakistan, where he helped that country build an enrichment plant. That plant became the basis of Pakistan's program to make highly enriched uranium for nuclear weapons. It also formed the nucleus for the growth of Dr. Khan's nuclear black market in which he and his associates made deals with Iran, Libya, and North Korea to supply these countries with uranium enrichment technologies. This black market spread across more than a dozen countries in Africa, Asia, and Europe. These activities underscore the proliferation danger of centrifuge technology.

Years before this proliferation, major powers including the United States and the Soviet Union joined in common interest in the 1960s to create the Nuclear Non-Proliferation Treaty (NPT), which entered into force in 1970. It was inherently discriminatory in that it defined two classes of states: the nuclear weapon states and the non-nuclear weapon states. The former included China, France, Russia, the United Kingdom, and the United States because they had tested nuclear weapons prior to January 1, 1967. They formed an exclusive club, but the NPT's article VI obliged these states to eventually eliminate their nuclear weapons and to join with all states to pursue a treaty on general and complete disarmament. The majority of the world's nations belonged to the latter category of non-nuclear weapon states. These states have the obligation under article III to accept safeguards on their peaceful nuclear programs and in exchange receive assistance under article IV from the nuclear suppliers to develop these programs. Notably, article IV does not explicitly mention enrichment and reprocessing technologies, but some states such as Brazil, Iran, and Japan have interpreted article IV as giving them the right to acquire such technologies.

To meet the safeguards obligation, member states of the IAEA created and approved comprehensive safeguards agreements, which are in effect as long as a state is a party to the NPT. While the non-nuclear weapon states are required to have comprehensive safeguards agreements on their nuclear programs, the nuclear weapon states are not so required but can voluntarily accept safeguards on all or parts of their peaceful nuclear programs; the weapons side of their nuclear programs would definitely be off-limits to safeguards inspectors. Comprehensive safeguards agreements were designed to provide accountancy on the declared nuclear facilities and materials in

[3] See, for example, Henry D. Sokolski, editor, *Falling Behind: International Scrutiny of the Peaceful Atom* (Carlisle, Pennsylvania: The Strategic Studies Institute Publications Office, 2008).

a state. The emphasis is on declared. The IAEA would have to trust that a state had declared all its nuclear activities. Although the IAEA charter does allow for special inspections, the IAEA Board of Governors has been loathe to approve application of this right in order to investigate suspected noncompliance with safeguards. In 1991, Romania gave the IAEA such access to clear up a suspected incident from the former regime of Nicolai Ceausescu. In 1993, the IAEA Board of Governors approved a special inspection of North Korea because of allegations that the North Korean government had not declared all the plutonium that had been separated from irradiated fuel at the Yongbyon 5 MWe reactor. Coincidentally, the early 1990s was when the IAEA had to come to terms with the loophole in comprehensive safeguards agreements.

In 1991, U.S. coalition military forces pushed Iraqi occupying forces out of Kuwait, which had been invaded by Iraq's military in late 1990. The coalition purposely did not march on Baghdad, but a defeated Iraq was made by the UN Security Council to open up for inspections to dismantle its programs dedicated to weapons of mass destruction. During the inspections on Iraq's nuclear facilities, it was discovered that Saddam Hussein's nuclear scientists and technicians were getting close to acquiring enough fissile material for a nuclear weapon, despite the fact that Iraq was a party to the NPT and had a comprehensive safeguards agreement with the IAEA. IAEA inspectors had regulatory inspected Iraq's declared nuclear facilities and materials, but undeclared facilities existed often right next door to declared facilities. In the undeclared nuclear program, Iraqi nuclear technicians were working on various uranium enrichment methods such as laser isotope separation, electromagnetic isotope separation, and gaseous centrifugation. These discovered activities raised serious concern in 1991. The IAEA Board of Governors launched an initiative for the agency to develop a more effective safeguards system that became known as the additional protocol to comprehensive safeguards agreements.

The additional protocol (AP) requires inspectors to assess whether there are any undeclared facilities or materials and to examine nuclear activities from mining of uranium (front end) to the handling of spent fuel (back end). It also provides for complementary access and short-notice inspections to suspect facilities. Usually the access should be given within 24 hours when inspectors are off site. When they are on site, they should be able to get access within two hours or even less time if "exceptional" circumstances warrant it. States that have signed and had the IAEA apply the AP have gone through a thorough investigation of their entire nuclear program and activities. Although the IAEA's recent directors-general have urged states to apply the AP, it has yet to become a mandatory requirement for all states.

Certain states have resisted or been opposed to applying the AP. Notable states that do not have an AP in force but do have a comprehensive safeguards agreement (CSA) in force include Argentina, Brazil, Egypt, Iran, Saudi Arabia, and Syria. There is not a "one size fits all" reason why these states and some others have not enacted the AP despite having a CSA with the IAEA. Argentina and Brazil have a regional agreement in which they monitor and inspect each other's facilities and materials as well as have this agreement in effect with the IAEA. The IAEA thus also periodically inspects these two countries' declared facilities and materials and verifies the completeness of the declarations. Brazil, however, has been particularly concerned about the intrusiveness of inspections in its enrichment facility, which it could use to make enriched uranium fuel for nuclear powered ships. There has been some speculation that Brazil does not want to reveal proprietary information about the enrichment facility. Moreover, Brazil has been a leading proponent of creating a non-discriminatory international system and consequently would want to keep pressure on the nuclear weapon states to move more quickly toward nuclear disarmament. Thus, Brazil does not want to

take on more safeguards until the nuclear weapon states take further positive action on disarmament. Argentina, as Brazil's regional rival, appears aligned similarly with this position. While Washington appears willing to continue nuclear trade relations with these states, the positions of Buenos Aires and Brasilia on the AP and safeguards raise consternation about whether the AP will ever become a universal standard. If these two states were fully supportive of the AP, further diplomatic pressure could be applied to more worrisome outlier states such as Iran and Syria.

Iran had voluntarily applied the AP until February 2006 when its nuclear program's case was brought before the UN Security Council; Tehran then suspended application of the AP. With the ongoing negotiations between Iran and the P5+1 states in 2014, the AP again has come before Iran as a minimum next first step to build confidence that its nuclear program is peaceful and can remain so. If the negotiations are to be successful in bringing Iran back into compliance with safeguards, Iran will have to go beyond the AP in order to accept and apply further monitoring and verification measures. A positive example set by Iran could exert political pressure on Egypt, Saudi Arabia, and Syria, states in the Middle East that have concerns with extra requirements on safeguards. Egypt has seen itself as a leading member of the non-aligned movement of developing nations and thus wants to keep pressure on the NWS to do more on nuclear disarmament. Saudi Arabia has expressed its concern about Iran's nuclear program and is waiting to find out if the P5+1 states can reach an acceptable deal with Iran. Riyadh's leaders have indicated that they could take steps to acquire nuclear weapons if Iran goes down that path. Positively, if Iran makes the effort to demonstrate clear peaceful intent and accepts adequate controls on its nuclear capabilities, the Saudi Arabia could come around to accepting the AP. Syria, as a state under civil war with an authoritarian government, has also been opposed to applying the AP. In 2007, Israel bombed a site in Syria where it was suspected that Syrian nuclear technicians were working with North Korean counterparts to build a nuclear reactor that could make plutonium. The IAEA has been investigating this incident and has been amassing evidence in support of this claim. Even if Iran accepts adequate monitoring and safeguards, it is unlikely that Syria will feel enough political pressure to follow suit. In sum, each of these states must be dealt with on a case-by-case basis.

Now consider the states that have applied the AP and been supportive of the IAEA's efforts to work toward a universal application. In 1997, the IAEA Board of Governors approved the AP for signature and entry into force for states parties to the NPT that have comprehensive safeguards agreements. But the Board did not go as far as to make the AP a mandatory requirement. During the 1990s, Australia was one of the leading governments developing the AP and pushing for its universal application. To lead by example, Australia was the first state to sign the AP and enter it into force, which Canberra did by the end of 1997. While Australia does not have nuclear power plants, it is a major exporter of mined uranium and has a radioisotope production facility and other nuclear research and development, including SILEX, a technique for laser isotope separation and enrichment of uranium. Canberra has for decades been a strong supporter of the international nonproliferation system and has worked closely with regional and global allies and partners.

Two of those regional partners are Japan and the Republic of Korea (ROK). Japan was the first major nuclear power producing state and non-nuclear weapon state to apply the AP, which it did by the end of 1999. Japan also stands out because it is the only non-nuclear weapon state (NNWS) with both enrichment and reprocessing facilities. Tokyo's leaders are mindful of their country's special status and thus took the steps necessary to exert a leadership role in safeguards. The ROK, another major nuclear power producing state, also was one of the first in this group of nations to implement the AP; it did so in 2004.

Australia, Japan, the ROK, and a few dozen other nations have been approved by the IAEA to belong to the Integrated Safeguards system. This system allows for reducing the burden of frequent safeguards for states that have demonstrated the absence of undeclared nuclear materials and facilities as well as consistently accounting for all declared materials and facilities. More and more, the IAEA is moving toward an information-driven safeguards system in addition to making qualitative determinations about states' safeguards.

The IAEA's latest complete report on safeguards implementation concludes that by the end of 2012, 60 states with both a CSA and an AP had accounted for all declared nuclear material and had no indications of undeclared material or activities. These states are Armenia, Australia, Austria, Bangladesh, Belgium, Botswana, Bulgaria, Burkina Faso, Canada, Chile, Croatia, Cuba, Czech Republic, Denmark, Ecuador, Estonia, Finland, Germany, Ghana, Greece, Holy See, Hungary, Iceland, Indonesia, Ireland, Italy, Jamaica, Japan, Jordan, Kuwait, Latvia, Libya, Lithuania, Luxembourg, Madagascar, Mali, Malta, Monaco, Netherlands, New Zealand, Norway, Palau, Peru, Philippines, Poland, Portugal, the Republic of Korea, Romania, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, The Former Yugoslav Republic of Macedonia, Turkey, Ukraine, Uruguay and Uzbekistan. The other 54 states that at that time had both a CSA and an AP had accounted for all their declared material, but the IAEA was still in the process of assessing the absence of undeclared material and facilities. This is not to say that there was evidence available that any of these states had undeclared material or facilities, but instead given the IAEA's limited resources (as discussed in a later section) it was still assessing these states.

For the 57 states with only a CSA, the IAEA concluded that declared nuclear material remained in peaceful activities. This conclusion was drawn for Algeria, Antigua and Barbuda, Argentina, Bahamas, Barbados, Belarus, Belize, Bhutan, Bolivia, Bosnia and Herzegovina, Brazil, Brunei Darussalam, Cambodia, Cameroon, Côte d'Ivoire, Dominica, Egypt, Ethiopia, Grenada, Guyana, Honduras, Islamic Republic of Iran, Kiribati, Lao People's Democratic Republic, Lebanon, Liechtenstein, Malaysia, Maldives, Myanmar, Nauru, Nepal, Oman, Papua New Guinea, Qatar, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, San Marino, Saudi Arabia, Senegal, Serbia, Sierra Leone, Solomon Islands, Sri Lanka, Sudan, Suriname, Syrian Arab Republic, Thailand, Tonga, Trinidad and Tobago, Tunisia, Tuvalu, Bolivarian Republic of Venezuela, Yemen, Zambia and Zimbabwe.

For states without a CSA, the IAEA could not draw any safeguards conclusions. These are Benin, Cape Verde, Djibouti, Equatorial Guinea, Eritrea, Guinea, Guinea-Bissau, Liberia, Federated States of Micronesia, São Tome and Principe, Somalia, Timor Leste, and Vanuatu.

For the three states that never signed the NPT, they have applied safeguards on specific facilities (as described in the IAEA's information circular document INFCIRC/66) but not their entire nuclear programs. As of December 31, 2012, safeguards were implemented at such facilities in India, Israel and Pakistan. In 2009, India signed an additional protocol just for specific facilities, which has not yet entered into force.

North Korea (DPRK) is an outlier state, as it is the only state to have withdrawn from the NPT. According to the IAEA, "Since 1994, the Agency has not been able to conduct all necessary safeguards activities provided for in the DPRK's NPT Safeguards Agreement. From the end of 2002 until July 2007, the Agency was not able, and since April 2009 has not been able, to implement any

verification measures in the DPRK and, therefore, could not draw any safeguards conclusion regarding the DPRK. Statements by the DPRK about uranium enrichment activities and the construction of a light water reactor in the DPRK continue to be deeply troubling."[4]

The IAEA's safeguards assessment for the NWS notes: "Under a voluntary offer agreement, the Agency applies safeguards to nuclear material in those facilities that have been selected by the Agency from the State's list of eligible facilities in order to verify that the material is not withdrawn from peaceful activities except as provided for in the agreement. In selecting facilities under voluntary offer agreements for the application of safeguards, the Agency takes into consideration factors such as: (i) whether the selection of a facility would satisfy legal obligations arising from other agreements concluded by the State; (ii) whether useful experience may be gained in implementing new safeguards approaches or in using advanced equipment and technology; and (iii) whether the cost efficiency of Agency safeguards may be enhanced by applying safeguards, in the exporting State, to nuclear material being shipped to States with comprehensive safeguards agreements in force. By implementing measures under the additional protocol in these five States with voluntary offer agreements, the Agency also seeks to obtain and verify information that could enhance the safeguards conclusions in States with comprehensive safeguards agreements in force."[5]

Finally, there is a group of states with a safeguards arrangement called the Small Quantities Protocol (SQP), which was intended for states with only small quantities of nuclear materials. In 2005, the IAEA Board of Governors called on these states to enact complete comprehensive safeguards agreements to replace the SQP, which was initially designed to streamline the safeguarding of states with only small amounts of nuclear material. As of the end of 2012, these SQP states included Afghanistan, Andorra, Barbados, Belize, Bhutan, Bolivia, Brunei, Cambodia, Cameroon, Dominica, Ethiopia, Fiji, Gabon, Grenada, Guyana, Haiti, Jordan, Kiribati, Kuwait, Kyrgyzstan, Lao Peoples Democratic Republic, Maldives, Mauritania, Mongolia, Myanmar, Namibia, Nauru, Nepal, New Zealand, Oman, Papua New Guinea, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Grenadines, Samoa, Saudi Arabia, Sierra Leone, Solomon Islands, Sudan, Suriname, Togo, Tonga, Trinidad and Tobago, Tuvalu, United Arab Emirates, Yemen, and Zambia.

To hasten universal compliance with safeguards, the IAEA published an action plan in September 2007. One of proposed actions was to apply peer pressure to convince more states to conclude comprehensive safeguards agreements. For example, Japan, a leading nuclear power producer with a strong commitment to nuclear disarmament, has hosted regional workshops on the benefits of safeguards.[6] The Republic of Korea has also hosted and supported such workshops. In particular, in Seoul in April 2009, there was the first meeting of the Asia-Pacific Safeguards Network. Australia and the ROK were initiators of this network--which is not meant to replace the work of the IAEA--but instead it is to complement the agency by providing additional means for professional development, encouragement for more nations in this region to apply the AP, information sharing, and in general cooperation and coordination.[7] The IAEA has also helped sponsor other safeguards workshops in other regions.

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[4] International Atomic Energy Agency, "Safeguards Statement 2012," Vienna, Austria, 2013.
[5] Ibid.
[6] Charles D. Ferguson, "Strengthening Nuclear Safeguards," *Issues in Science and Technology*, Spring 2008.
[7] Director General, Australian Safeguards and Non-Proliferation Office, Annual Report 2008-2009, Australian Government, 2009, p. 21.

Other states with additional protocols should emulate Australia, the ROK, and Japan, by working closely with the IAEA to convince all nations to complete and implement these agreements. In further choosing the appropriate partners and clients to enhance nonproliferation, the United States should make the AP a condition of sale for nuclear energy cooperation. Japan, for instance, has this requirement for its nuclear sales to clients.

Support to the International Atomic Energy Agency and the Nuclear Suppliers Group

The IAEA faces serious financial and resource constraints. In 1985, the Geneva Group of the 14 major funders of the UN and affiliated international organizations decided to hold the UN and these organizations to zero real growth as much as possible in order to achieve greater efficiencies and encourage cost savings. Zero real growth means that the regular budgets can increase to keep pace with inflation but will not be increased beyond that amount. These organizations can help make up shortfalls in the regular budgets by having member states give voluntary contributions to extra-budgetary funding. While some UN organizations needed the cost trimming and enforced fiscal discipline, the U.S. Office of Management and Budget (OMB) and other international assessors have rated the IAEA as a highly efficient agency with the OMB stating that the IAEA gives "100 percent value-for-money."[8] During the almost 30 years since zero real growth was implemented, the amount of nuclear material needing safeguarding has gone up by about six times and the number of facilities has increased by almost three times. While there have been times in the past ten years in which the IAEA has received bump ups in real growth, most of the time the agency has had to struggle along with a relatively meager regular budget while demands from member states for safeguards, safety, security, and technical cooperation work from the IAEA keep going up. The consequences are that the IAEA has been forced to defer investments and upgrades in critical infrastructure such as the Safeguards Analytical Laboratories in Seibersdorf, Austria, and has no reserve funds to respond to crises. Moreover, the IAEA has been unable to meet member state demands for technical cooperation assistance, having to pay for most of this work from extra-budgetary funds. Extra-budgetary funds have also been needed to pay for a significant portion of the IAEA's nuclear security program, which has increased substantially in the past decade. Fortunately, this program has been upgraded recently to the status of a division with an increase of funding in the regular budget.

But the overall funding needed for this program and the other programs of the IAEA are not sufficient. In 2013, for example, the Board of Governors was at an impasse on deciding about the budget for 2014 and 2015. The Board decided to form a Working Group on Financing the Agency's Activities. While in 2012-2013 the Board decided on a real growth of 2.2 percent, the 2014 budget went up only 0.3 percent in real growth, and the 2015 budget will be held to zero real growth.[9]

Some options have been suggested to ensure that the IAEA has adequate funding. For example, in 2006, Thomas Shea, a leading expert on the IAEA and safeguards, recommended that each state's contribution to the budget should be proportional to its nuclear energy use. He argued that this is

[8] C M Toomey, A J Kurzrok, E T Wyse, and J M Swarthout, "Alternate Funding Sources for the International Atomic Energy Agency," Pacific Northwest National Laboratory, Report for the U.S. Department of Energy, September 2012.
[9] James Martin Center for Nonproliferation Studies and the Vienna Center for Disarmament and Non-Proliferation, "IAEA Budget: 2014," Factsheet, September 2013.

fair because a state's financial stake in safeguards is linked to the benefits it gains from use of peaceful nuclear energy. If the international nuclear safety, security, and safeguards systems fail, all states that benefit from nuclear energy will tend to suffer. Dr. Shea examines five particular mechanisms to provide for adequate funding: create an endowment, assess a surcharge on nuclear energy generation, leverage financial institutions, use market mechanisms, and receive contributions from the nuclear industry. While a detailed description of these mechanisms is beyond this report, it is worthwhile to read Dr. Shea's paper.[10] Notably, a 2012 Pacific Northwest National Laboratory report recommends creation of an endowment.[11]

The United States should encourage existing and potential partner states as well as client states to increase their contributions to the IAEA at least commensurate with their use of nuclear energy. Moreover, these states should cooperate with the United States and other like-minded states to provide real growth to the IAEA's budget to close gaps in financing critical infrastructure, creating a reserve fund to respond to crises, and ensuring sufficient resources to meet the challenges of the increased facilities and materials needing safeguards and security.

While the IAEA includes almost all states in the world, the Nuclear Suppliers Group (NSG) is a more select set of about 50 nations that include the major suppliers of nuclear technologies and related goods and services. The NSG was formed in response to an international crisis. When in 1974, India shocked the nonproliferation system by detonating a so-called peaceful nuclear explosive. Such a device is still weapon usable. The political shock came in part from how India obtained the plutonium for the explosive device. It reprocessed irradiated fuel from the CIRUS reactor that had been supplied by Canada and had used heavy water supplied by the United States. These suppliers had intended for purely peaceful useful of that reactor. At that time, the Zangger Committee, also known as the Nuclear Exporters Committee that was formed from the Article III safeguards requirement in the NPT, was focused on requiring states outside the NPT to institute IAEA safeguards before they would be permitted to import certain items, known as the trigger list. But this list and the exclusive membership of the committee (only NPT member states were committee members) were too restrictive. In 1975, France (which was then not a member of the NPT but was a major nuclear supplier) joined with several members of the Zangger Committee to form the Nuclear Suppliers Group.

The NSG has formed guidelines and not international laws. These guidelines ask importing states to provide assurances to suppliers that they will only use the imported technologies for peaceful purposes. The client states are also requested to maintain adequate physical security on imported materials and equipment. The guidelines are made of two parts. Part I lists materials and technology that are specifically for nuclear use. This list was first published in 1978 in response to India's diversion of plutonium from the CIRUS reactor. Part II lists dual-use items, which have non-nuclear applications as well as nuclear uses. For example, certain kinds of lasers and machine tools can be considered Part II items. The NSG adopted Part II in 1992 after the shock of finding out how close Iraq came to developing a nuclear weapon by exploiting nearly unfettered access to dual-use items. In 2004, the NSG further expanded its guidelines to include a "catch-all" mechanism, "which

[10] Thomas E. Shea, "Financing IAEA Verification of the NPT," Paper for the Nonproliferation Policy Education Center, November 2006, http://www.npolicy.org/article.php?aid=360&tid=30
[11] Toomey et al., op cit.

authorizes members to block any export suspected to be destined to a nuclear weapons program even if the export does not appear on one of the control lists."[12]

The NSG is facing significant challenges. China and Russia have cited "grandfather" clause exemptions to supply Pakistan and India, respectively, with nuclear technologies when those two South Asian states have been under nuclear sanctions. However, in recent years, the United States has asked and received NSG permission to carve out in exemption for India under the U.S.-India nuclear deal. While the NSG guidelines request full-scope safeguards on a non-nuclear weapon state's entire nuclear program, India is one of three states in the special category of an NNWS (under the terms of the NPT) but a non-signatory state that made nuclear weapons. New Delhi pledged to place part of its program under safeguards with several reactors and enrichment and reprocessing plants outside of safeguards. Islamabad would like to follow suit, but the United States and other major political powers in the NSG are not supportive of making a similar exemption, especially considering Pakistan's proliferation history with the A. Q. Khan network.

The NSG has been moving toward requiring further criteria on transfers of enrichment and reprocessing (ENR) technologies. While the NSG has generally sought to limit further transfers, it has urged development of multi-national nuclear fuel cycle enterprises. A number of NSG member states were opposed to text in proposed guidelines that would appear to compel them to use so-called black box arrangements, which would shield sensitive design details of enrichment plants from a recipient state. While the agreed final text of the guidelines did not require black boxing, it strongly encouraged ENR possessors from not sharing such information with those who do not have such knowledge.[13]

Another challenge for the NSG is how to respond to the evolving globalized nuclear trade system and how to block development of further nuclear black markets such as the Khan network. Related to these issues are the scoping questions of whether and how to pare down the Part I and II lists. That is the "basic decision the NSG must make about whether to aspire to comprehensive listing of goods or instead focus on effective implementation of a shorter list."[14] The NSG needs to do a much better job at reporting and sharing among members information about export denials regardless of the choices made about the lists. Denials provide great insight as to potential or actual proliferation in the works; an assessment of denial information over time and geographic distribution can further help spot proliferation.

Development of Proliferation-Resistant Technologies

Proliferation proof nuclear technologies do not exist, but technologies can often be made more proliferation resistant. The design of a reactor, for instance, can be well suited to make fissile material that is not desirable for nuclear weapons, while other types of designs can be more proliferation prone due to characteristics such as online refueling or the relative ease in making

[12] "The Nuclear Suppliers Group (NSG) at a Glance," Fact Sheet, Arms Control Association, October 2012.
[13] Fred McGoldrick, "The Road Ahead for Export Controls: Challenges for the Nuclear Suppliers Group, *Arms Control Today*, January/February 2011.
[14] Mark Hibbs, "The Future of the Nuclear Suppliers Group," Report, Carnegie Endowment for International Peace, 2011.

weapons-grade plutonium. Proliferation-resistance assessments have been the subject of several reports.[15] The purpose here is not to review those assessments, but recommend that the United States insist that partners wanting to develop enrichment and reprocessing need to apply thorough pathway analysis of potential proliferation susceptibility for the various technologies. Moreover, these partners need to work toward deployment of technologies that have been assessed to have higher levels of proliferation resistance. For example, the United States is working closely with the Republic of Korea in a ten-year study of pyro-processing, which appears to have increased proliferation-resistance over the more traditional method of PUREX reprocessing. Pyro-processing, if used as intended, would not separate out pure plutonium from irradiated fuel but instead would produce a mixture of different fissionable elements whereas PUREX results in the complete separation of plutonium. Furthermore, the United States should seek assurances from states pursuing or using reprocessing or pyro-processing that there are adequate safeguards that would include near-real time monitoring of the materials and activities in the facilities.

Physical Protection Measures Applied to Nations' Nuclear Materials and Facilities

Like safeguards, physical protection of nuclear materials and facilities has been an evolving process. In 1980, the Convention on Physical Protection of Nuclear Material (CPPNM) was opened for signature and by 1987 the convention entered into force; presently, there are 148 states parties. But the CPPNM only applied to protection of nuclear materials in international transport. This was not sufficient; thus in 2001, the United States and other like-minded states pushed for an amendment that would extend the physical protection requirements to facilities and materials in domestic use. The amendment was opened for signatures in 2005, but the entry into force has not been fully completed with the United States still struggling to get the Senate to enact its domestic implementing legislation (despite the fact that in 2012 and 2013 the House of Representatives passed such legislation.) Therefore, the United States is in the awkward position of calling on other states to enact the amended CPPNM but has not fully carried out this enactment itself. As of June 27, 2014, 77 states (including leading nuclear power producing states in Europe as well as Japan and the ROK) have accepted or ratified the amendment. To enter into force, the amendment needs another 22 states to accept or ratify it. Several member states of the IAEA have been revising the document INFCIRC/256 to provide the written standards and guidance necessary to implement these improved physical protection requirements.

A more recent companion convention is the International Convention to Suppress Acts of Nuclear Terrorism (ICSANT). Russia was the lead state pushing for the creation of ICSANT in 1996. Russia has had serious concerns about acts of radiological terrorism as well as possible nuclear terrorism by Chechen rebels. ICSANT opened for signatures in 2005 and entered into force in 2007. It includes definitions of nuclear and radiological terrorism and their criminalization as well as measures to improve cooperation among states in securing facilities and materials.

[15] See, for example, George Pomeroy et al., "Approaches to Evaluation of Proliferation Resistance of Nuclear Energy Systems," Comparison of GIF and INPRO methodologies, http://www.iaea.org/INPRO/CPs/PRADA/approaches.pdf

Efforts and Commitments to Global and Regional Nuclear Security Systems

As the amended CPPNM and ICSANT show, the international community of nations has been moving toward more substantive conventions and thus binding commitments for nuclear security. But many experts and government officials have been concerned that the pace of improvements and commitments has been too slow. The George W. Bush administration took significant action after the 9/11 terrorist attacks to redouble U.S. and other nations' efforts in nuclear and radiological security through such mechanisms as the G8 Global Partnership and the Global Threat Reduction Initiative. While campaigning for the presidency in 2008, then-Senator Barack Obama called attention to the need for even more coordination and high-level leadership on these issues. He pledged that if elected his administration would convene the first ever Nuclear Security Summit, which was held in Washington, DC, in April 2010. More than 40 heads of state participated and the focus was primarily on securing fissile material used in civilian and commercial applications. Then-Korean President Lee Myung Bak decided to carry the figurative torch to Seoul for the second Nuclear Security Summit in 2012. At this summit, the agenda expanded somewhat to include attention to security of radioactive sources while keeping the main focus on security of fissile materials that could power nuclear weapons built by non-state actors.[16] In addition, the Seoul summit had major involvement of the nuclear industry and helped to showcase the large strides the ROK has made in becoming a leading nuclear power producing state. Moreover, because the Seoul summit took place just one year after the accidents at the Fukushima Daiichi Nuclear Power Plant in Japan, significant discussion occurred about making nuclear power safer and what steps countries should take to achieve better safety such as forming strong, independent nuclear regulatory agencies. Japan is in the process of doing that; the ROK and China have also made substantial reforms to their regulatory systems.[17] The most recent Nuclear Security Summit happened in The Hague in March 2014 with the Dutch government as the host. President Obama has pledged to reconvene the summit again in the United States in 2016, the last full year of his presidency.

Because of the concern for summit fatigue, national leaders are not seriously considering a repeat of the summit every two years forever. They, however, have largely recognized that nuclear security is not some end state but a continuing process and must be sustained to achieve high standards. It is expected that the IAEA's Nuclear Security Division will provide the continuing coordinating role. Individual states can also play a highly constructive role as leaders.

An outstanding example of this continuing role for individual states is the ongoing formation of several centers of excellence for nuclear security. From the first Nuclear Security Summit, a number of nations announced plans for centers of excellence: China stated that it would cooperate with the United States (which has provided substantial funding for China's center of excellence); Japan launched a regional support center and has since held many workshops including participants from Asian nations; Italy announced that it would create a school for nuclear security; Kazakhstan said it was considering forming an international training center; and India announced that it was going to create a nuclear energy center that would also include security. Even before the 2010 summit, other centers or related training programs were getting underway: The United States was working with Brazil as well as building up capacities in several other nations; the Republic of Korea had announced that it would create a nuclear security center; the United Kingdom was also taking similar

[16] "2012 Seoul Nuclear Security Summit: Key Facts," Republic of Korea, 2012.
[17] Michelle Cann, Kelsey Davenport, and Sarah Williams, "The Nuclear Security Summit: Progress Report," An Arms Control Association and Partnership for Global Security Report, July 2013.

action in 2009 (but in 2010, a change of government forced a reversal of this decision because of funding concerns); the IAEA was working on six nuclear security support centers (in Morocco, Colombia, Ghana, Pakistan, Tanzania, and Malaysia) and was planning on seven more (in Chile, Cuba, Turkey, Kazakhstan, South Africa, the Philippines, and Jordan); and the European Commission had a broader agenda for its center of excellence to include chemical, biological, radiological, and nuclear issues.[18] Investment in security "enables the sustained uses of nuclear energy because public confidence is vital to the enterprise."[19] Major considerations going forward for these centers are whether they can coordinate effectively with each other and receive adequate financial, technical, and personnel backing from governments as well as industry.

Another means for states as well as corporations to support the further development of better practices for nuclear security is to fund and participate in workshops, conferences, and related programs of the World Institute for Nuclear Security (WINS). WINS began in September 2008 and has hundreds of members including many governments, corporations, and nongovernmental organizations. It has served as a forum that has brought together thousands of people in workshops and meetings. WINS recently started an academy to train management and security personnel so that they can achieve professional certification. It is in the U.S. and other partners' interest to continue to support WINS and related forums.

Effectiveness of Export Control Laws and Regulations

Export controls can block or delay efforts of states that want to acquire weapons of mass destruction. These controls are not meant to be perfect. Determined proliferating states have often shown that they can eventually find ways to acquire desired materials, equipment, and knowhow. Nonetheless, export controls can play important roles in buying time for diplomatic efforts to work, engendering trade by building trust among suppliers, enhancing deterrence by denial, increasing the likelihood of interdicting illicit transfers of technology, and spotting suspicious technology acquisition trends. The foundations of an effective export control system are competent licensing authorities, means of enforcement, and governmental partnership with industry. Also, states are most effective when they coordinate their export controls internationally and multi-nationally. Enforcement has been the weakest link because identifying WMD-related technologies can be very difficult, customs and border officials can be poorly motivated, and few governments actually carry out investigations let alone follow through and punish violators.[20] Experts who have studied export control systems (such as Michael Beck), agree that the international export control system must be strengthened; the regimes are slow moving (bound by consensus rules), have limited information sharing, and are thought to be not responsive to globalization and the challenges of terrorism and proliferation that crosses borders.[21] Beck and other analysts such as Peter Crail have looked to the UN Security Council Resolution 1540, which passed unanimously on April 28, 2004 and called on all UN member states to improve protections against weapons of mass destruction, as a means to assess and promote more effective export controls.

[18] Alan Heyes, "An Assessment of the Nuclear Security Centers of Excellence," Policy Analysis Brief, The Stanley Foundation, May 2012.
[19] Sharon Squassoni, "Building a Nuclear Security Framework From the Ground Up: Encouraging Coordination Among Centers of Excellence in Northeast Asia," Policy Analysis Brief, The Stanley Foundation, March 2013.
[20] Michael Beck, Executive Director, "Elements of an Effective Export Control System," Presentation, Center for International Trade and Security, The University of Georgia
[21] Ibid.

Crail's 2011 report for CSIS takes the data that are publicly available from a 2008 assessment of the 1540 Committee in order to examine what states involved in or wanting to develop nuclear power programs have done in nuclear export controls.[22] Of the 115 states that made their data available, 19 have nuclear energy programs and are NNWS,[23] 15 are considering nuclear energy programs,[24] and four are NWS and have nuclear energy programs (France, Russia, the United Kingdom, and the United States). These states make up the majority of the NSG with 31 states in these lists being members of the NSG. The 1540 Committee identified 26 distinct provisions for determining a state's compliance with export controls with respective to having a legal framework and enforcement mechanisms.[25] As Crail's table in his report shows, the top performing countries in both legal framework and enforcement include Australia at the very top, then the Netherlands, New Zealand, the United Kingdom, and the United States. The Republic of Korea is not far behind these top performers; it scores above average in both legal framework and enforcement. There is a noticeable gap among many nations between these two measures; remarkably many nations score average to above average in having the requisite legal framework but fall short in the enforcement measures. I recommend that the United States leverage such data to encourage current and potential partners as well as client states in nuclear energy to fulfill export control measures across the board in both legal framework and enforcement mechanisms.

Conclusions and Recommendations

The United States should further strengthen the nonproliferation and nuclear security international system through a cooperative approach that will partner with states that have:

- Enacted and implemented the additional protocol to comprehensive safeguards agreements.
- Organized and supported regional workshops to encourage more states to implement the AP in order to move toward a universal application of more effective safeguards.
- Made the enacted AP or a commitment toward enacting the AP for clients as a condition of nuclear sales.
- Invested in research and development for further improving monitoring and safeguarding nuclear energy programs.
- Contributed funding to the IAEA commensurate with a state's use of nuclear energy and further supported real growth of the IAEA's regular budget to meet the challenges of increasing amounts of nuclear materials and facilities needing safeguards, safety, and security.

[22] Peter Crail, "Measuring Nuclear Export Controls in Nuclear-Powered Nations and Nuclear Aspirants," CSIS, September 2011.
[23] Armenia, Belgium, Brazil, Bulgaria, Canada, Czech Republic, Finland, Hungary, Italy, Kazakhstan, Netherlands, Romania, Slovakia, South Africa, South Korea, Spain, Sweden, Switzerland, and Ukraine. See International Atomic Energy Agency, "Facilities Under Agency Safeguards or Containing Safeguarded Material on 31 December 2008, available from http://www.iaea.org/Publications/Reports/Anrep2008/table_a23.pdf.
[24] Albania, Australia, Belarus, Chile, Ecuador, Estonia, Georgia, Ireland, Latvia, Libya, Morocco, New Zealand, Poland, Portugal, and Thailand.
[25] The matrix was developed by the committee's panel of experts and formally adopted as an assessment tool in 2005. The committee's description of the matrix can be found at http://www.un.org/sc/1540/1540matrix.shtml.

- Shared information about denials of nuclear exports among the members of the Nuclear Suppliers Group and further coordinated among these suppliers to limit the spread of nationally owned and controlled enrichment and reprocessing facilities.
- Invested in research and development for making nuclear energy systems more proliferation resistant.
- Created centers of nuclear security excellence or given substantial support to others' centers as well as performed extra steps under the framework of the Nuclear Security Summit process to further improve global nuclear security.
- Enacted and implemented the amendment to the Convention on Physical Protection of Nuclear Material (CPPNM) or at least taken steps to put this amendment before a state's appropriate legislative body for enactment and implementation.
- Put into effect export controls that meet the requirements specified in the UN 1540 Committee's list of 26 provisions for both legal framework and enforcement mechanisms.