Civilian Nuclear Energy and Nuclear Weapons Programs: The Record

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In considering how to reduce the contribution of the civilian nuclear energy system to the proliferation of nuclear weapons in the future, it is important to examine what aspects of civilian nuclear energy have contributed to nuclear weapons programs in the past. Below, we provide a brief summary of the contribution of civilian nuclear energy to many of the known nuclear weapons programs of individual states (both successful programs and ones that were terminated short of acquiring nuclear weapons).[2] Three points should be kept in mind in considering this history: (1) while the availability of technology and expertise is important to a nuclear weapons program, the available data suggests that states' decisions on whether to move toward or away from nuclear weapons are more affected by a variety of security, political, and bureaucratic factors;[3] (2) safeguards and export control arrangements have been greatly strengthened since some of these events occurred, making it difficult for them to be repeated in the future (though at the same time, technologies have continued to diffuse); and (3) states seeking nuclear weapons have also acquired important technologies – from precision explosives to flash X-ray cameras to high-speed switches for setting off a bomb – from other civilian industries unrelated to nuclear energy.

United States, Soviet Union, Britain: These states' nuclear weapons programs had no significant contribution from civilian nuclear energy; nuclear weapons were developed in dedicated military programs before civilian nuclear energy existed. Once civilian programs were established, there were substantial interconnections between civilian and military programs, including transfers of civilian material for military use (a connection that was largely severed after a time in the United States and Britain).

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[2] The list in this paper is intended to be illustrative, not comprehensive. Nuclear weapons efforts or explorations that took place in Switzerland, Australia, Egypt, Germany, Japan, Italy, Indonesia, Norway, Canada, and Algeria are not discussed. It is worth noting that a number of these countries have access to large quantities of fissile material and high levels of nuclear technology but chose not to acquire nuclear weapons. Useful summary discussions of many of the programs described here can be found in Rodney W. Jones and Mark G. McDonough, *Tracking Nuclear Proliferation: A Guide in Maps and Charts, 1998* (Washington DC: Carnegie Endowment for International Peace, 1998), available at http://www.ceip.org/programs/npp/track98.htm.

[3] Indeed, if those who argue that institutional factors are particularly crucial in shaping states' nuclear weapons decisions are correct, it may be that nuclear energy's impact in building up groups of nuclear experts and advocates, and providing a power base for them, may be at least as important as any specific technological factor. In the words of one advocate of the instutional influence school, "the biggest proliferation impact of Atoms for Peace may not have been the spread of little reactors but the spread of little Atomic Energy Commissions, many of which became bomb advocates." James Walsh, personal communication.

France: France's initially civilian nuclear program provided the base of expertise (and some key advocates) for its later dedicated military program (which had substantial interconnections with the civilian program, with both under the Commissariat de L'Energie Atomique, and material for the weapons program sometimes produced in power reactors).[4]

China: China's nuclear weapons were developed in a dedicated military program with no major technological contribution from civilian nuclear energy. Civilian energy served as a fig leaf for an agreement with the Soviet Union under which critical weapons assistance was provided, which was justified as an agreement on "peaceful uses" of atomic energy. Some minor uranium processing procedures were adapted from U.S. technologies declassified for civilian purposes.[5]

Israel: Israel's plutonium production reactor and reprocessing plant at Dimona were provided by France, ostensibly for civilian purposes, but without safeguards requirements and under cover of substantial secrecy (particularly in the case of reprocessing). Heavy water was provided by Norway under peaceful use assurances (later violated). Weapons activities were successfully hidden from limited 1960s-era U.S. visits intended to confirm peaceful use.[6] Israel was perhaps the only case where lack of uranium supplies was a significant constraint. Israel reportedly acquired uranium from South Africa, Argentina, Niger, and others;[7] in 1968, Israel apparently acquired 200 tons of uranium for Dimona by removing it from a Belgian ship on the high seas (after it had been purchased in a front transaction by firms acting as Israeli agents).[8] Allegations that a large incident of HEU unaccounted for at the U.S. NUMEC facility in the 1960s was caused by theft of some 100 kg of HEU for transport to Israel, while never fully resolved, are probably incorrect.[9]

India: Plutonium for India's first nuclear test (ostensibly of a "peaceful nuclear explosive") was produced in a research reactor provided by Canada for civilian purposes under a 1956 agreement not requiring safeguards (which did not yet exist); the

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[4] For brief discussions of the early days of the French, British, and Chinese nuclear weapons programs, see Robert S. Norris, Andrew S. Burrows, and Richard W. Fieldhouse, *British, French, and Chinese Nuclear Weapons: Nuclear Weapons Databook Volume V* (Boulder, CO: Westview, 1994). For a fuller discussion of the French program, see Lawrence Scheinman, *Atomic Energy Policy in France Under the Fourth Republic* (Princeton, NJ: Princeton University Press, 1965).

[5] For the classic discussion of the Chinese program, see John W. Lewis and Xue Litai, *China Builds the Bomb* (Stanford, CA: Stanford University Press, 1988).

[6] The most comprehensive account of the Israeli program is Avner Cohen, *Israel and the Bomb* (New York, NY: Columbia University Press, 1998).

[7] See, for example, Leonard Spector, *The Undeclared Bomb* (Cambridge, MA: Ballinger, 1988), pp. 165-87.

[8] See Elaine Davenport, Paul Eddy, and Peter Gillman, *The Plumbat Affair* (Philadelphia, PA: J.B. Lippincott, 1978).

[9] See discussion in Seymour Hersh, *The Samson Option* (New York, NY: Random House, 1991) pp. 241-257.

reprocessing technology was based on U.S. PUREX technology declassified under the Atoms for Peace program, and the reprocessing plant was designed in part by a U.S. firm, again on grounds of peaceful use. Heavy water came from the United States, under peaceful use assurances; India also covertly acquired many tons of heavy water from Norway and other countries, apparently to allow it to operate its heavy-water reactors without safeguards. India also has an unsafeguarded pilot-scale uranium enrichment facility. India's military and civilian nuclear energy programs have been substantially integrated from their inception.[10]

Pakistan: The HEU for Pakistan's nuclear weapons was produced at a plant using centrifuge technology stolen from a contractor for the civilian Urenco enterprise in Europe.[11] Pakistan also secretly acquired substantial nuclear technology (possibly including nuclear weapon design information) from China. Previously Pakistan had focused on the plutonium route to the bomb, but a Pakistani-French deal under which France was to provide a plutonium reprocessing plant (ostensibly for civilian purposes) was cancelled after U.S. pressure in 1977; Zhafikar Ali Bhutto, then Prime Minister, later wrote that at the time, "all we needed" for a "full nuclear capability" was "the nuclear reprocessing plant."[12] Later, however, senior officials in the program indicated to U.S. experts that the reprocessing plant would have served as a training facility for nuclear weapons program personnel, with a separate facility to be used to provide the actual bomb material.[13] Weapons plutonium is now believed to be being produced in an unsafeguarded reactor provided by China, ostensibly for civilian purposes.

South Africa: South Africa's nuclear program was initially civilian, and received substantial foreign assistance, which allowed it to build up an indigenous technical base which was important for its weapons program. HEU for South Africa's nuclear weapons was enriched using an indigenously developed technology related to Germany's Becker nozzle process; despite the indigenous development, a significant amount of related technology was clandestinely acquired from abroad, and there was substantial help from Germany in particular. Construction of the enrichment plant was publicly announced and justified as being in support of South Africa's civilian nuclear energy program.[14]

Iraq: Iraq's nuclear weapons program was based primarily on overtly and covertly acquiring ostensibly civilian nuclear technologies from abroad. Iraq first pursued a plutonium route to nuclear weapons. Plutonium was to be produced in a research reactor

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[10] For a comprehensive discussion of the Indian program, see George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation*. (Berkeley, CA: University of California Press, 1999).
[11] For a discussion of Pakistan's program, see Jones and McDonough, *Tracking Nuclear Proliferation*, op. cit.; see also David Albright and Mark Hibbs, "Pakistan's Bomb: Out of the Closet," *Bulletin of the Atomic Scientists*, July/August 1992.
[12] Quoted in Leonard Spector, *Going Nuclear* (Cambridge, MA: Ballinger, 1987), p. 103.
[13] George Perkovich, personal communication.
[14] See, for example, David Albright, *South Africa's Secret Nuclear Weapons* (Washington DC: Institute for Science and International Security, 1994).

provided by France; but this reactor was bombed by Israel in 1981. Iraq then turned to covert uranium enrichment as its principal approach to nuclear weapons, and acquired a wide range of uranium enrichment technologies from civilian programs around the world, including declassified electromagnetic isotope separation ("calutron") technology once used in the United States, and controlled gas centrifuge enrichment technology acquired covertly from a variety of civilian industrial sources. Iraq successfully hid both large undeclared facilities and covert activities at declared facilities from the IAEA inspection regime; Iraq used Iraqi nationals at the IAEA to learn about IAEA procedures and prepare for fooling inspectors. Had the 1991 Gulf War not intervened, Iraq would soon have acquired a nuclear weapons capability. Increasingly tight export controls, however, definitely delayed the Iraqi program's progress. After invading Kuwait, Iraq launched a "crash" program to build a nuclear weapon before the assembling international coalition attacked; for this purpose, Iraq intended to use the HEU from its safeguarded research reactor. After the Iraqi experience, both international safeguards approaches and international export controls were strengthened, in an attempt to close some of the loopholes Iraq had exploited.[15]

Iran: Iran's nuclear program began as a civilian effort. While there remains some debate as to the extent to which Iran has decided on a focused, large-scale nuclear weapons program, there is no doubt that entities within the Iranian government have for years been attempting to purchase technologies relevant to a nuclear weapons program. The civilian program, which received assistance from the United States and Germany under the Shah, and has received substantial assistance from Russia and (to a lesser extent) China under the current government, has contributed to the base of expertise for the bomb effort (at whatever scale that effort is proceeding), and has been used extensively as a cover for purchases intended for the weapons program. Iran's weapons program originated under the Shah. Teheran has attempted to purchase a wide range of ostensibly civilian nuclear technologies related to both uranium enrichment and plutonium production for many years, in a covert procurement program covering countries all over the world.[16] In a 1994 "secret protocol" with Russia, subsequently canceled under U.S. pressure, Iran attempted to purchase a gas centrifuge enrichment facility (ostensibly to support its civilian nuclear energy program).[17] Iranian agents have also attempted to acquire fissile material stolen from facilities in the former Soviet Union.[18] The United States has expressed concern that Russian institutes may be providing technologies related to fissile material

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[15] For discussions of Iraq's nuclear weapons program, see the various reports of the IAEA Action Team (the more recent ones have been compiled by the Nuclear Control Institute at http://www.nci.org/sadb.htm); David Albright and Khadir Hamza, "Iraq's Reconstitution of Its Nuclear Weapons Program," *Arms Control Today*, October 1998; and David Albright and Robert Kelley, "Has Iraq Come Clean at Last?" *Bulletin of the Atomic Scientists,* November/December 1995.

[16] For a summary see Jones and McDonough, *Tracking Nuclear Proliferation*, op. cit.

[17] See David Albright, "An Iranian Nuclear Bomb?" *Bulletin of the Atomic Scientists*, July-August 1995.

[18] See Jones and McDonough, *Tracking Nuclear Proliferation*, op. cit., and Matthew Bunn, *The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material* (Washington DC: Carnegie Endowment for International Peace and Harvard Project on Managing the Atom, 2000), available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/Nextwave.

production to Iran, and has sanctioned two Russian institutes for such activities. Recently, Iran attempted to buy equipment for laser isotope separation from Russia (with lasers at power levels below the threshold specified for control in Nuclear Suppliers Group guidelines), but Russia suspended this deal under U.S. pressure. In addition, the United States has strongly opposed Russia's agreement with Iran to build a large light-water reactor (or possibly several) at Bushehr; among the U.S. concerns is that the program to train hundreds of Iranian specialists at Russian nuclear institutes (including the institute where most Russian nuclear weapons designers have been trained), while ostensibly focusing only on civilian technologies, will substantially contribute to the base of expertise required for a nuclear weapons program, and will provide opportunities to forge personal connections that could lead to illicit sales of sensitive nuclear technologies.

Taiwan: Taiwan's covert nuclear weapons program (abandoned in the 1970s under U.S. pressure, and then restarted and abandoned again in the 1980s, also under U.S. pressure) was pursued under the cloak of its civilian nuclear energy program, which received (and continues to receive) substantial technology and assistance from abroad. A heavy water reactor similar to that India used to produce the plutonium for its first explosive was provided by Canada, under peaceful use assurances, along with U.S.-origin heavy water. The United States provided a small amount of separated plutonium for research purposes, some of which was fabricated into plutonium metal (a form unlikely to have been intended for civil use) in an ostensibly civilian facility. Reprocessing technology was provided by a French firm and a Norwegian expert, and also sought from the United States, Germany, and others. An ostensibly civilian nuclear research institute was located next to a secret military facility, with the same security systems serving both. Evidence from IAEA and U.S. inspections in the 1970s strongly suggested that Taiwan was planning to divert material from its safeguarded facilities to its weapons program. Under intense U.S. pressure, the Taiwanese government then provided assurances to the United States that it would not reprocess, dismantled the reprocessing facilities, and sent the separated plutonium back to the United States. In 1987, however, construction of a new series of hot cells for reprocessing began, in violation of the previous commitments, and was stopped only after intense U.S. pressure.[19] Most of the plutonium-bearing spent fuel from the Canadian research reactor was shipped to the United States in the late 1980s to resolve proliferation concerns.

South Korea: South Korea began a secret nuclear weapons program (based on plutonium production and reprocessing) at about the same time it began construction of its first civilian power reactor, in the early 1970s. The United States soon detected the secret program and threatened Seoul with the withdrawal of U.S. support if the program continued. South Korea agreed to end the program, and joined the NPT in 1975. Later

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[19] For a useful summary of these events, see David Albright and Corey Gay, "Taiwan: Nuclear Nightmare Averted," *Bulletin of the Atomic Scientists*, January/February 1998; see also William Burr, ed., "New Evidence on Taiwanese `Nuclear Intentions'," National Security Archive Electronic Briefing Book No. 19, October 13, 1999, available at http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB20/.

that year, France announced that it was selling South Korea a reprocessing plant; Seoul canceled the deal after the United States intervened, fearing the plant could contribute to a renewed weapons program. Seoul threatened to launch an unsafeguarded reprocessing program in the late 1970s when President Carter was moving to withdraw U.S. troops from South Korea, but backed off when the troops stayed.[20] South Korea re-initiated a reprocessing effort in the 1980s, but canceled it again under U.S. pressure. In a 1991 denuclearization agreement with North Korea (never fully implemented), Seoul pledged not to establish either enrichment or reprocessing capabilities.

Argentina: Argentina has the oldest and most successful civilian nuclear program in South America, which also served as a cloak for what appears to have been a nuclear weapons effort. Argentina received a research reactor from the United States in the 1950s, built several more of its own, and ultimately built two heavy-water power reactors provided by Canada and Germany. During the 1970s, Argentina built an unsafeguarded plutonium reprocessing facility, reportedly with Italian and German help. The small initial facility and a larger one then under construction were shut down because of economic constraints and U.S. pressure in 1990. In 1983, the Argentine junta announced that it had succeeded in enriching uranium at a secret gaseous diffusion enrichment facility at Pilcaniyeu. While this facility was claimed to be for peaceful purposes, Argentina's reactors did not require enriched fuel, and the secrecy with which it had been built raised concerns that it was intended to supply a nuclear weapons program. It is believed never to have enriched material above 20%. The weapons program was abandoned in the 1980s after a civilian government came to power and reached a rapprochement with Brazil, and all Argentina's facilities are now under safeguards.[21]

Brazil: As early as 1953, Brazil sent a military officer to Germany to attempt to purchase centrifuge technology for uranium enrichment; this was blocked by the United States, which later reached a peaceful nuclear cooperation agreement with Brazil, and provided a research reactor. Nevertheless, Brazilian enrichment R&D using German nozzle technology continued. In 1975, Brazil and Germany agreed on a nuclear "deal of the century" in which Germany was to provide several reactors and a complete nuclear fuel cycle, including both an enrichment plant and a reprocessing facility, under international safeguards. (The deal was later drastically scaled back, due to delays, economic constraints, and U.S. pressure.) At about the same time, Brazil launched a secret, unsafeguarded "parallel program" run by the military, divided into segments run by different services, with the Navy pursuing centrifuge enrichment (ultimately successfully establishing an enrichment facility), and the Army pursuing plutonium production. Personnel trained in the safeguarded program with Germany were transferred to the weapons program, and technologies from the safeguarded program are believed to have been used in both the unsafeguarded enrichment facility and a small plutonium

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[20] See Mitchell Reiss, *Without the Bomb: The Politics of Nuclear Proliferation* (New York: Columbia University Press, 1988).

[21] See discussion in Jones and McDonough, *Tracking Nuclear Proliferation*, op. cit.

separation facility. The weapons program was cancelled under a later civilian government, and following the Brazil-Argentina rapprochement, all of Brazil's nuclear facilities are now under safeguards.[22]

Sweden: Sweden's nuclear program was originally an integrated program for both nuclear energy and nuclear weapons, based on plutonium production in heavy-water reactors. R&D on nuclear weapons was carried out in the 1950s, while the public civilian program pursued development of the heavy-water reactors. Delays in the heavy-water reactors, combined with a U.S. offer of safeguarded LWR technology and fuel, led Sweden's industry to drop its support for the heavy-water option, leaving continued development with no civilian rationale. By the mid-1960s, the weapons program had been dropped, because of lack of domestic political support. Today, all of Sweden's nuclear activities are under international safeguards.[23]

Yugoslavia: Yugoslavia pursued a secret nuclear weapons program, under the fig leaf of its civilian nuclear research program, for many years. The Soviet Union supplied research reactors and other assistance to the ostensibly civilian effort. The weapons program focused primarily on the plutonium route, with reprocessing technology from Norway; complete plans for a reprocessing plant were delivered from Norway in 1962. The program ended in the early 1960s, but was reinitiated after India's test in 1974. The weapons program relied on the production of plutonium in the civilian program. The program was terminated in 1987. Yugoslav scientists, however, still have experience in a broad range of technologies related to nuclear weapons, and nearly 50 kilograms of fresh 80% enriched HEU fuel – enough for a nuclear weapon – provided by the Soviet Union for peaceful research, is located at the Vinca research institute near Belgrade, where many of the former weapons program scientists are employed.[24]

Nuclear Material Thefts: There have been several confirmed cases of theft of plutonium or HEU during the 1990s, primarily from civilian facilities in the former Soviet Union, where the security system was never designed to cope with the situation it now faces. The cases that are known involved opportunistic thieves without clear arrangements in place to sell the material to a weapons program. U.S. and other intelligence agencies, however, have warned that both Iran and Iraq, among others, have networks of procurement agents in place in the former Soviet Union seeking the technologies of weapons of mass destruction, including fissile material for their weapons

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[22] For a good account through the late 1980s, see Leonard S. Spector and Jacqueline R. Smith, *Nuclear Ambitions* (Boulder, CO: Westview, 1990), pp. 242-263; for a brief update to 1998, see Jones and McDonough, *Tracking Nuclear Proliferation*, op. cit.

[23] See, for example, Paul Cole, *Sweden Without the Bomb: The Conduct of a Nuclear-Capable Nation Without Nuclear Weapons* (Santa Monica, CA: RAND, 1994); Thomas B. Johannsen, "Sweden's Abortive Nuclear Weapons Project," *Bulletin of the Atomic Scientists,* March 1986; and the account in William J. Long, "Trade and Technology Incentives and Bilateral Cooperation," in David Cortright, ed., *The Price of Peace: Incentives and International Conflict Prevention* (Lanham, MD: Rowman and Littlefield, 1997).

[24] See William Potter, Djuro Milanic, and Ivo Slaus, "Tito's Nuclear Legacy," *Bulletin of the Atomic Scientists*, March/April 2000. Milanic and Slaus were participants in the weapons program.

programs. One of the thefts in the former Soviet Union (of 1.5 kilograms of HEU from the Luch Production Association in Podolsk in 1992) represented perhaps the only known case of a knowledgeable insider exploiting his understanding of the weaknesses of the safeguards and accounting system to divert small amounts of material at a time (a particularly challenging scenario for safeguards).[25]

Lessons: Civilian nuclear energy is by no means the driving force behind nuclear proliferation; that role falls to states' security concerns, desires for status, and a variety of domestic political and bureaucratic factors. Most countries that embarked on nuclear weapons programs established dedicated military facilities to produce the material for their nuclear weapons rather than relying on their civilian nuclear industries. Civilian nuclear energy, however, appears to have played three key roles. First, the world civilian nuclear energy system has been a key source for the technology used in these dedicated fissile material production facilities. It is clear that export controls have significantly slowed some nuclear weapons programs, but need to be maintained and strengthened in the future. Second, civilian nuclear energy has also served as a justification or fig leaf for construction of facilities, acquisition of technologies, and other activities that were actually intended for a nuclear weapons program (or were intended to serve both purposes), allowing countries to acquire technologies they would not have been permitted to acquire in the absence of a "peaceful uses" justification. Third, through civilian nuclear energy programs, states have built up their indigenous technical base of trained people and experience in nuclear technologies, which ultimately contributed to their weapons programs; indeed, in at least some cases, these experts also were key domestic advocates of pursuing nuclear weapons.

While it appears that most states prefer to establish dedicated fissile material production facilities, in at least a few cases states have planned on using material diverted from safeguarded civilian facilities for their weapons efforts (e.g., Iraq's plan to use the HEU from its safeguarded research reactor for its "crash" bomb program, Taiwan's apparent steps toward diversion in the 1970s, and Yugoslavia's plan to rely on plutonium from its civilian program), or have actively sought to purchase or steal nuclear material from elsewhere (e.g., Israel's acquisition of uranium in the Plumbat affair, Iran and Iraq's recent attempts to acquire weapons-usable material in the former Soviet Union). Thus, it would appear that there is some legitimacy to concerns over the broad availability of HEU and plutonium in civilian use, and that continued efforts to strengthen safeguards and to ensure that all weapons-usable material worldwide is secured and accounted for to the highest practicable standards should be urgent priorities.

With respect to R&D on proliferation-resistant civilian nuclear technologies, several conclusions can be drawn from this history:

- Some skepticism is in order concerning how large an impact on proliferation risks development of new, more proliferation-resistant nuclear energy systems would have. The key technologies that might be acquired from the civilian sphere – uranium

[25] See Matthew Bunn, *The Next Wave*, op. cit.

enrichment and plutonium production and separation – already exist and are not going to go away. Unless new technologies were adopted extremely widely (which has not occurred with any major new nuclear reactor or fuel cycle technology in decades), their impact would probably be modest.

- Technologies that reduced or eliminated the rationale for civilian use of HEU or separated plutonium (such as low-enriched fuels for research reactors and approaches to extending uranium resources that never separate plutonium into weapons-usable forms), or that allowed existing stockpiles of separated plutonium to be transformed rapidly into forms that were no longer usable in weapons, could ease the burdens on safeguards and security systems and reduce the risk of diversion or theft of weapons-usable material.
- Reducing the need for uranium enrichment could reduce states' ability to justify acquiring enrichment technology to support their civilian energy program (though there is already a growing consensus among supplier states not to provide this technology to additional countries).
- Similarly, higher burnup and other approaches that reduced whatever attractions plutonium reprocessing may have could reduce states' ability to justify acquiring reprocessing technology to support their civilian energy program.
- Approaches that greatly reduced the complexity of present technologies such as the light-water reactor could reduce the requirement to build up a large indigenous technical base to support a nuclear energy program, thereby reducing the base from which nuclear weapons programs have been built. Thus, approaches such as factory-built reactors with long-life cores, which could be delivered to a site and produce electricity with a minimum of domestic infrastructure being required, could potentially make a significant contribution to reducing the proliferation risks associated with expanding civilian nuclear energy.