

**Nuclear Weapons Proliferation:
What is in Store for the Next Millennium**

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The international nuclear non-proliferation regime is a collection of treaties, agreements and commitments applied to peaceful uses of nuclear energy designed to ensure that special fissionable and other materials, services, equipment, facilities, and information are not used in any way to assist a non-weapon state to acquire nuclear explosive devices. The Non-Proliferation Treaty (NPT), the International Atomic Energy Agency (IAEA) safeguards, the Treaty on the Prohibition of Nuclear Weapons in Latin America (Tlatelolco Treaty), the Nuclear Suppliers Group (agreement and list), the interpretations of “Especially Designed and Prepared” (the “Trigger” list) are all part of this regime.¹ During the past 40 years, or so, this regime has had its successes and failures. Several countries initiated and subsequently shutdown their nuclear weapons development efforts, and the Non-Proliferation Treaty (NPT) has been ratified by all but a handful of countries and extended indefinitely. Beyond the five countries that are declared nuclear weapon states under the NPT, the spread of nuclear weapons now appears to be limited to Israel, India, and Pakistan, none of whom have signed the NPT or joined the IAEA. Some have argued that this provides a clear demonstration of the success of the regime.

Apart from this demonstrated success, there are several non-nuclear weapon states who are currently seeking, or who have recently sought, a nuclear weapons capability, including Iraq, North Korea, Iran, and Libya; and there was at least one non-state terrorist group, Aum Shinrikyo cult, in this category. No doubt there are other so-called nascent nuclear weapon states that are taking steps now to reduce the time period to acquire nuclear weapon should a decision be made in the future to do so. Thus, in the foreseeable future—well into the next century—it will be important to retain an effective international non-proliferation regime to ensure that civil nuclear activities are not used for weapon purposes.

During the past decade the international safeguards regime has been marked by two glaring failures, exclusive of events surrounding North Korea’s efforts to obtain nuclear weapons. First, is the failure by the IAEA and other elements of the international safeguards regime to detect in a timely fashion the Iraqi nuclear weapons program and its relationship to nuclear activities under IAEA safeguards. The scope of the Iraqi weapons program was only divulged as a consequence of the Gulf War and its aftermath, to the extent that the scope is known. The international community, through the IAEA and its “Programme 93+2,” has taken important steps to strengthen international safeguards to lessen the likelihood of a repetition of the Iraqi case, primarily by giving the IAEA wider latitude to inspect undeclared nuclear facilities and other research facilities that lack fissionable material inventories subject to safeguards. It remains to be seen how effective these improvements will be.

Second, is the failure to prevent the diversion of kilogram (kg) quantities of weapon-usable nuclear materials—plutonium and highly-enriched uranium (HEU)—from civil nuclear facilities in Russia following the collapse of the Soviet Union. The international safeguards regime could not, and cannot, provide timely warning of a diversion of significant quantities of nuclear weapon-usable materials from the civil nuclear programs in Russia and other states of the former Soviet Union to any number of states or non-state groups seeking nuclear weapons.

¹ Export control efforts have been expanded to cover missile technology, and chemical and biological dual use equipment and facilities, for example, through the Missile Technology Control Regime, the Australia group and the Wassenaar list.

There is neither adequate physical security nor adequate material control and accounting of nuclear weapon-usable materials in Russia and other newly independent states. In this instance it has not even dawned on the leadership of the international civil nuclear community that this in large measure is their problem—and a problem of their own making. The nuclear community was not responsible for the collapse of the Soviet Union. But the availability of large inventories of inadequately safeguarded weapon-usable fissile material is a direct consequence of the international nuclear community's promotion of the use of HEU in civil research and test reactors, the commercial separation of plutonium in reprocessing plants, and the use of plutonium fuels in civil reactors. Moreover, unlike in the case of Iraq, the international nuclear community has failed to mobilized itself and put in place adequate safeguards to ensure that diversion of plutonium and HEU from civil nuclear programs cannot happen in the future under similar circumstances.

In spite of Programme 93+2 and other improvements in IAEA safeguards, the United States does not believe IAEA safeguards are adequate and ultimately does not rely on them. Nuclear weapon program activities in Taiwan were not detected by IAEA safeguards, and it was the United States, not the IAEA that forced Taiwan and South Korea to curb their plutonium programs. More recently, the United States has opposed the sale of civil power reactors to Iran by Russia. Iran has signed the NPT; the Russian-made VVER-1000 reactors use a non-weapon usable low-enriched uranium fuel; the fuel would be returned to Russia; and while in Iran the fuel would be under IAEA safeguards. Nevertheless, the United States has actively opposed this sale and the sale of a research reactor fueled with 20 percent enriched uranium, claiming that Iran is sponsoring terrorism, receiving technology for its missile program from Russian agencies, and pursuing a nuclear weapons program.

Global security would not be improved if, following the example of Japan, South Korea, Taiwan and Iran were to pursue a closed fuel cycle, to construct a pilot reprocessing plant, and to begin stockpiling plutonium ostensibly for civil purposes. And the Natural Resources Defense Council (NRDC) categorically rejects the notion of a discriminatory safeguards regime that permits civil plutonium stockpiling in some countries, but not in others.

My colleagues and I have long argued that the commercial use of nuclear weapon-usable materials—separated plutonium and HEU—is incompatible with adequate safeguards. There is simply no credible way to adequately safeguard “bulk handling” facilities, such as chemical separation plants and enrichment plants producing HEU, without making these activities prohibitively expensive. Current IAEA safeguards are hopelessly inadequate in this regard. Diversions cannot be detected in a timely fashion. The inventory differences, or “material unaccounted for” (MUF), are too large—as evidenced by the large plutonium MUF incurred at the Japanese Tokai reprocessing plant—and the IAEA safeguards at these facilities cannot meet the “timely warning” criterion of an adequate safeguards system. Moreover, the IAEA uses a technically incorrect definition of what constitutes a “Significant Quantity” (SQ) of direct-use nuclear material. The IAEA significant quantities—8 kg of plutonium and 25 kg of HEU—are about eight times too high.² Using early-1950s weapon design techniques that are now widely

² Thomas B. Cochran and Christopher E. Paine, “The Amount of Plutonium and Highly-Enriched Uranium Needed for Pure Fission Nuclear Weapons,” NRDC, Revised April 13, 1995.

discussed in the open literature, one can construct a pure nuclear fission weapon with a yield of one kiloton with about one kg of weapon-grade plutonium or about 3 kg of HEU. Modern thermonuclear weapons are typically constructed with deuterium and tritium boosted fission primaries containing on average about 3 kg of weapon-grade plutonium and having primary yields of several kilotons. Clearly, were the IAEA honest about how much plutonium or HEU is needed to make a nuclear weapon, it would be evident that adequately safeguarding bulk handling facilities is far more difficult task than the IAEA is willing to admit.

There are several ongoing developments related to modern nuclear weapon design that will make it all the more important to control—we would say eliminate—the commercial use of direct-use fissile materials. Qualitative design principles of boosted weapons are now being published in the open literature.³ But this pales compared to what we can expect early in next century in the way of openly available weapon design information.

The United States has stopped nuclear explosive testing and has signed the Comprehensive Test Ban Treaty (CTBT). As a consequence the U.S. Department of Energy (DOE) is now proposing to spend \$4 billion to \$4.5 billion annually—\$60-67 billion over the next 15 years—on its nuclear weapons “Stockpile Stewardship and Management Program” (SSMP). In constant dollars this rate of expenditures is more than the United States spent on average during the Cold War for designing, testing and building and retiring warheads, and when the stockpile was typically about twice as large as it is today. The Stockpile Stewardship part of this DOE program is predicated on achieving a fundamental understanding of nuclear explosives, and thus in many instances, unclassified advances in the scientific understanding of nuclear explosive phenomena.⁴ The Stockpile Stewardship program seeks to sustain and even enhance U.S. capabilities, formerly dependent on nuclear explosive testing, to design and prototype nuclear weapons and “certify” changes to existing weapon types.

One of the objectives of DOE’s Stockpile Stewardship Program is to retain a cadre of scientist who are experts in the various nuclear weapon technologies. This is a principal objective of the inertial confinement fusion (ICF) program and the new National Ignition Facility (NIF) being built at Lawrence Livermore National Laboratory. In order to retain these scientist, DOE is relaxing the classification rules so that they can publish their research in the open literature. U.S. nuclear weapon scientists already are rapidly generating and releasing a wide range of data related to the design of nuclear weapons, including data on basic high energy-density physics, thermonuclear burn, chemical high explosive, and equations-of-state of higher atomic weight materials. Under the Stockpile Stewardship program, new experimental facilities, such as NIF, are being constructed to provide in the absence of explosive nuclear weapon

³ André Gsponer and Jean Pierre Hurni, “The Physical Principles of Thermonuclear Explosives, Inertial Confinement Fusion, And the Quest for Fourth Generation weapons,” International Network of Engineers and Scientist Against Proliferation, Technical Report No. 1, March 1998.

⁴ Christopher E. Paine and Matthew G. McKinzie, “End Run: The U.S. Government’s Plan for Designing Nuclear Weapons and Simulating Nuclear Explosions under the Comprehensive Test Ban Treaty, NRDC, April 1998 (Rev. 1).

testing, nuclear weapon design data, and data to validate new weapon codes. Much of the data gathered in these facilities will be unclassified.

Another component of the Stockpile Stewardship program is the Accelerated Strategic Computing Initiative (ASCI), projected to cost some \$4 billion between now and 2003. An objective of ASCI is to develop by 2003, computers that will be 100,000 times more powerful than today's supercomputers. With these new computer codes, DOE seeks to achieve a "virtual testing" capability, whereby vastly improved computer models of nuclear explosive performance, validated against past nuclear tests as well as experiments conducted in an array of powerful new above and below-ground testing facilities, are intended initially to offset, and perhaps ultimately to replace, the loss of data from underground testing. If current trends persist, we can anticipate that lower cost, more widely available, commercial computers will have the power and capacity of the supercomputers developed some ten years earlier.

Within the ASCI program, DOE has launched the Academic Strategic Alliances Program (ASAP), a partnership between the U.S. nuclear weapons program and the university community that will cost several hundred million dollars over the next five years. The contributions of ASAP to Stockpile Stewardship are in basic (but largely interdisciplinary) scientific research, computer hardware and software research for computer architectures based on massively parallel processing, and the union of these in simulation of complex systems. Under ASAP, for example, the California Institute of Technology will be assisting DOE in developing improved simulations of chemical high explosive detonations, shock compression of heavy metals, and the study of related hydrodynamic instabilities. All of this work will be unclassified.

As the U.S. post-CTBT weapons program matures, we can anticipate that sometime within the first quarter of the next century, a tremendous amount of nuclear weapons design information and related computer design codes will be widely available in the open literature, and far more powerful computers will be widely available. Modern thermonuclear weapon designs will no longer be the sole purview of today's nuclear weapon states. Even in the absence of explosive nuclear testing, if there are to be any remaining technical barriers to obtaining nuclear weapons of sophisticated design, they primarily will be in the form of constraints on the availability of direct-use nuclear material—separated plutonium and HEU. Whether such a barrier exists is a decision that will be made by the leadership of the civil nuclear establishment. It is in your hands. The choice is yours.

Instead of tightening controls over direct-use materials, some nuclear industry leaders have suggested that for safeguards purposes a distinction should be drawn between weapon-grade and reactor-grade plutonium. The Canberra Commission, for example, suggested such a possibility in the Annex to its report, based on briefings the Commission received from the IAEA staff.⁵ The IAEA staff then cited the Canberra Commission as authority for its own proposal, and said it was a potential cost cutting measure worthy of further investigation.⁶ Plutonium of any isotopic can be used to manufacture nuclear weapons, although in the case of

⁵ Canberra Commission, "Report of the Canberra Commission on the Elimination of Nuclear Weapons," April 1996, Annex A, p. 91.

⁶ Bruno Pellaud, "Safeguards: The Evolving Picture," IAEA Bulletin, Vol. 38, No. 4, 1996.

plutonium containing some 80 percent or more of the isotope Pu-238 the rate of heat generation makes the plutonium particularly unattractive as a weapons material. While reactor-grade plutonium results in a lower probable yield in pure fission weapon designs due to pre-ignition of the nuclear chain reaction, modern boosted fission weapons and boosted primaries of thermonuclear weapon are designed so that pre-ignition is impossible. In other words, the boosted primaries are designed so the chain reaction is initiated at the moment of criticality. As such the warhead's yield cannot be affected by a strong neutron flux from the explosion of another warhead, thereby increasing the probability of fratricide or kill by an enhanced-radiation ABM warhead. This means that from the standpoint of pre-ignition and confidence in the attainment of design yield, the use of reactor-grade plutonium in modern boosted designs has the same utility as weapon-grade plutonium.

The critical mass of reactor-grade plutonium is about 25 percent greater than that of weapon-grade plutonium—but still less than half that of uranium enriched to greater than 90 percent—resulting in a slightly heavier weapon. The heat generation rate and radioactivity of reactor-grade plutonium are some 5-10 times greater than weapon-grade plutonium, but these drawbacks can be readily managed by changes in the warhead design and manufacturing procedures. In sum, it simply makes no sense technically to draw a distinction for safeguard purposes between weapon-grade and reactor grade plutonium.

Several trends—improved understanding of the physics of thermonuclear explosions, increased public availability of this information, increased computer capabilities, and increased availability of tritium for fusion research—will in the future place more countries in a position of being able to develop boosted fission weapons. Boosting overcomes the principal limitation of reactor-grade plutonium. Hence reactor-grade plutonium is *gaining*, not losing, in significance as a nuclear weapons material. Safeguards of reactor-grade plutonium should be strengthened, not weakened; and safeguards should be put on a sound technical footing.

Next, I wish to address two additional challenges to the nuclear industry and its leadership. In an article appearing in last month's newsletter of the American Physical Society, John Holdren, of Harvard University, identified four science and technology challenges of the next 50 years:

- (1) eliminating weapons of mass destruction;
- (2) meeting global energy needs while limiting the atmospheric concentration of carbon dioxide to less than twice its preindustrial value;
- (3) sharply reducing the global rate of loss of biodiversity; and
- (4) preventing the population of the planet from exceeding 9 billion people.

I am confident that we can all agree that these are worthy challenges. The potential role of nuclear power comes into play with regard to the first two issues.

With respect to greenhouse gases, the first step is for states to decide on an equitable allocation for limiting green house gas emissions. While this has not been completed for all nations, the protocol adopted at Kyoto on December 11, 1997, established emission limits for industrial nations. NRDC advocates the adoption by the United States of a carbon tax or the use

of tradable emission allowances to force a reduction in greenhouse gas emissions. For example, if carbon emission allowances trade for about \$50/tonne of carbon, or \$12/tonne of CO₂, this is roughly equivalent to \$0.005/kwh for natural gas-fueled plants, or \$0.012/kwh for coal plants. This would not be sufficient to make new nuclear plants competitive with new gas plants in the United States, where a new gas plant costs about \$0.03/kwh. The effect in other countries might be quite different. We would strongly oppose the use of nuclear power to reduce greenhouse gas emissions if the nuclear power industry intends to rely on commercial use of separated plutonium, i.e., the closed fuel cycle. Increasing the commercial use of separated plutonium to reduce CO₂ is not progress.

While nuclear industry leaders want to believe that nuclear power has an important role to play in meeting global energy needs while limiting CO₂ emissions, very little attention appears to have been given to the role of nuclear power in eliminating nuclear weapons. In the past decade we have witnessed the end of the Cold War, several countries have shut down their nuclear weapons development efforts and have joined the NPT, which has been extended indefinitely, explosive testing of nuclear weapons has ended and 149 countries have signed the CTBT, improved intergovernmental relations and greater interdependence of states as a result of the globalization of their economies is making the nuclear weapons option less attractive for the vast majority of non-nuclear weapon states, society has rejected reliance upon, and the stockpiling of, chemical and biological munitions and former military leaders are now calling for the elimination of nuclear weapons. For the first time in 50 years there is the very real prospect of achieving deep reductions with the goal of eliminating of all nuclear weapons—the most lethal of the three predominant classes of weapons of mass destruction.

While this prospect is real, there are still major obstacles that must be overcome. First, the political and strategic relationships among several weapon states—between the United States and Russia, the United States and China, India and China, India and Pakistan, and Israel and its neighbors—must be altered significantly to reduce the perception by these countries that a nuclear deterrent capability is essential to their national security. For example, although it has been almost nine years since the fall of the Berlin wall and seven years since the collapse of the Soviet Union, the United States and Russia have yet to decide what kind of strategic relationship each wants with the other, much less decide on what steps must be taken to achieve this new relationship and agree on a plan to implement these steps. Instead the United States has resurrected old fears by an expanded NATO closer to the Russian border, and Russia has retaliated by abandoning its “No First Use” declaratory nuclear weapons policy, and has decided to retain thousands of tactical nuclear weapons to counter the new NATO threat. Similarly, when the right-wing Hindu nationalist Bharatiya Janata Party (BJP) recently assumed power in India, it announced its intention to carry out a strategic defense review to decide whether to build nuclear weapons. Clearly, much greater effort must be devoted to improving strategic relationships among the weapon states.

Second, the nuclear weapons production infrastructure in these the nuclear weapon states must be eliminated, sharply curtailed or redirected if we are to achieve deep reductions in the number of nuclear weapons. Russia, for example, still operates four nuclear warhead assembly plants and two plutonium pit production plants. Russia today also has three operational plutonium production reactors, two operational tritium production reactors and three operational

chemical separation plants. It is difficult to foresee the Pentagon giving up its “hedge” and other active reserve nuclear weapons and its large strategic reserves of nuclear weapon materials as long as Russia retains such a huge infrastructure for the production of nuclear warheads.

Third, the civil nuclear infrastructure in several nuclear weapon and non-weapon states must be altered so that nuclear weapons are not retained as a hedge to protect against breakout and rapid reconstruction of nuclear arsenals using inventories of weapon-usable materials in the civil power sector. The civil nuclear fuel cycle and the nuclear weapon-materials production facilities are highly integrated in some nuclear weapon states, particularly in Russia and China. This will make it difficult to eliminate a real or perceived breakout threat if these dual purpose facilities are retained to support closed fuel cycles of civil power reactors.

Japan is a non-nuclear weapons state; its citizenry abhor nuclear weapons and its political and military leaders profess to have no interest in obtaining them. On the other hand, Japan has a robust program of plutonium chemistry and metallurgy and is stockpiling tens of tons of weapon-usable plutonium in its civil nuclear power program. Japan also has a robust ICF program which, like the U.S. ICF program, will provide Japan with a cadre of scientists with expertise in the physics of thermonuclear explosions. Although Japan has shown no interest in developing a nuclear weapons program, military planners in the United States, Russia and China, in developing their own security plans, will focus primarily on Japan’s future capabilities, not just on Japan’s good intentions. As a hedge against a future nuclear weapons breakout by Japan, they will argue for the retention of their own nuclear weapons and strategic nuclear material inventories.

For the past half-century policies and practices related to commercial nuclear power and nuclear weapons have been inextricably intertwined. This relationship has fostered one of the strongest public criticisms against meeting global energy needs with nuclear power, namely, that the reliance on this technology should be opposed where it results in the commercial separation, stockpiling and use of nuclear weapon-usable fissile materials—principally separated plutonium and HEU. The future does not have to be this way. You, the leaders of the civil nuclear power industry, have an important role to play. As we move into the next millennium, you need to ask yourselves, do you want a world safe for nuclear power or a world safe for nuclear weapons? If it is the former you should shut down your reprocessing plant and HEU-fueled reactors, stop stockpiling plutonium and help us eliminate nuclear weapons.