Emerging demands on national nuclear material accounting systems

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Abstract

This paper provides an overview of how national nuclear material accounting systems are evolving as a consequence of expanded safeguards requirements, international policy initiatives, as well as those changes dictated by other distinct national-level priorities. It also argues that global nuclear energy development, changes in prevailing nuclear fuel cycle policies, and the negotiation of nuclear nonproliferation and arms control agreements could require further changes in material accounting practices that move beyond the current incremental evolution. These developments would usher in a radically different nuclear landscape that would require fundamental shifts in the design and operation of national nuclear material accounting systems to ensure operational efficiency and global security.

Introduction

International and national policy initiatives aimed at increasing nuclear security have put specific emphasis on the role of nuclear material accounting (see for example the IAEA's Additional Protocol, U.N. Security Council Resolution 1540, the communiqué from the 2010 Nuclear Security Summit, the Global Initiative to Combat Nuclear Terrorism Statement of Principles, Cooperative Threat Reduction efforts, Nuclear Cooperation Agreements, etc.). At least one goal (if not the only goal) of each initiative is to reduce the likelihood that nuclear materials could be diverted from peaceful purposes and used to develop weapons or sow terror.

The elements of these initiatives directed at nuclear material accounting intend to build on the capabilities of existing national accounting systems, which are expansive but fragmented and often offer only a shallow snapshot of nuclear material holdings. In the context of a range of possible future scenarios for the use of nuclear energy worldwide and deep cuts in nuclear weapons stockpiles, states are likely to require a fundamentally new standard of nuclear material accounting, one that prioritizes detailed, continuous tracking of all potentially dangerous nuclear materials regardless of whether they are under civilian or military control, or are used to produce nuclear energy or deployed as nuclear weapons.

By examining ongoing policy initiatives, examples of how national nuclear material accounting systems are evolving, and potential trends in global nuclear energy development and nuclear weapons reductions, this paper will identify potential requirements for future national nuclear material accounting systems that could provide the type of comprehensive accounting needed.

National nuclear material accounting systems

The primary goal of most national nuclear material accounting systems is to track the location, quantity, and composition of nuclear materials and to report this information to the International Atomic Energy Agency (IAEA) in order to ensure compliance with Safeguards Agreements and other international

commitments. Nuclear material accountancy is the "fundamental safeguards measure," according to the IAEA, in ensuring that declared nuclear materials are not used for or diverted to the manufacture of nuclear weapons.[1] All non-nuclear weapon states that are party to the Nuclear Non-Proliferation Treaty (NPT) and that have signed a Safeguards Agreement with the IAEA are obliged to set up a state system of accounting for and control of nuclear materials (SSAC).

The IAEA lays out the basic requirements for SSACs in "The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons." According to this document, facilities containing safeguarded nuclear materials need to designate material balance areas, the physical spaces within which nuclear material accounting occurs. The SSAC is expected to keep records that show the inventory of nuclear material in each material balance area and changes in that inventory, including "receipts into and transfers out of the material balance area." They are also required to be able to measure the amount of material that comes and goes from its inventory, as well as periodically measure the total physical inventory of materials in specific balance areas. States are expected to provide the IAEA with reports documenting changes in material balance area inventories within at most two months of each change and with reports documenting total "book inventories" at least twice a year. While the requirements of specific SSACs are more detailed than this description suggests and have evolved over time, these basic requirements remain unchanged.

Within the basic requirements laid out by the IAEA, nations have discretion about how they set up and run their own nuclear material accounting systems. Some states maintain both facility-level accounting systems and national-level systems that incorporate data from all facilities and prepare the reports necessary to meet international and national obligations. In practice, most states' systems are set up with the primary purpose of complying with their IAEA obligations and therefore closely mirror IAEA requirements. The exceptions include states with extensive nuclear material holdings, nuclear fuel cycle facilities, or international nuclear cooperation agreements, and states that have nuclear weapons. These states tend to have additional requirements for their national nuclear material accounting systems, including tracking nuclear energy-related obligations to cooperative states, complying with arms control agreements and threat reduction commitments, and fulfilling national-level or supranational-level safety and security regulations. Most states with nuclear weapons have separate accounting systems to track materials in operational nuclear warheads.

Recent policy initiatives

A spate of recent policy initiatives have established expanded, detailed requirements for national nuclear material accounting systems. These requirements have widened the categories of materials that require detailed accounting and improved the access of national and international authorities to up-to-date information on material stockpiles. Other initiatives have merely emphasized the need to improve material accounting as one part of larger security goals. Some of the major initiatives that fall into these categories are outlined below.

[1] International Atomic Energy Agency (IAEA), "Nuclear Material Accounting Handbook," Services Series 15, May 2008, p. 1.

Additional Protocol. Because the nuclear material accounting systems of a large majority of the states with nuclear materials are primarily bound by IAEA restrictions, changes to these rules have a widespread effect on the baseline demands placed on accounting systems. The adoption of the IAEA's "Model Protocol Additional to the Agreement(s) Between State(s) and the IAEA for the Application of Safeguards" (commonly referred to as the "Additional Protocol") in 1997 impacted the safeguards requirements of signatory states, including the demands placed on nuclear material accounting systems. The model Additional Protocol notes that many of its new nuclear material reporting requirements do not necessitate detailed material accounting, however, in practice, states rely on their accounting systems to provide the additional required reporting. In some instances, this requires accounting systems to be adapted or applied to materials for which reporting was previously not required.

For instance, Article 2 of the model Additional Protocol requires states to regularly declare the quantity, location, and use of small amounts of plutonium and uranium that total 1 kilogram or less, quantities that were previously permitted to be exempted from safeguards. The Additional Protocol also established new reporting requirements for nuclear materials that are designated for non-nuclear activities, including industrial processes where the materials are recoverable after use, prior to their use in those activities. It also requires reporting on the location and the processing of intermediate or high-level waste containing plutonium, highly enriched uranium, and uranium 233 on which safeguards have been formally terminated. As will be discussed later in this paper, the adoption of the Additional Protocol has led states to enact new domestic regulations and rely on nuclear material accounting to fulfill additional reporting requirements.

In general, the requirements of the Additional Protocol widen the base of information on which IAEA officials rely to ensure compliance with national commitments. This additional information supports the IAEA's shift in emphasis to "information-driven safeguards." Rather than relying so substantially on facility-level material accounting reports to ensure that materials aren't diverted, information-driven safeguards take a state-level approach, where officials evaluate information from a range of sources—environmental monitoring, data on the trade of nuclear technologies, satellite imagery, etc.—as they determine a state's compliance.[2]

UNSCR 1540. In response to growing concerns about the potential availability and use of biological, chemical, and nuclear materials by non-state actors, the United Nations Security Council adopted Resolution 1540 in April 2004. Among its many provisions, the resolution emphasizes the need for states to "develop and maintain appropriate effective measures to account for and secure [materials related to nuclear, chemical, and biological weapons] in production, use, storage, or transport." In outlining its goal as the "appropriate and effective" accounting of (for the purposes of this paper) nuclear materials, the resolution defers to the specific arrangements and best practices outlined as part of other multilateral initiatives, such as IAEA Safeguards Agreements and the Additional Protocol. Indeed, in documenting their actions to come into compliance with the nuclear material accounting elements of resolution 1540,

[2] Kory W. Budlong Sylvester and Joseph F. Pilat, "The Evolution of Information-Driven Safeguards," International Atomic Energy Agency, IAEA-CN-184/100.

some states cite as evidence changes that they made to their nuclear material accounting systems and procedures in response to their obligations under the Additional Protocol.[3]

Other multilateral initiatives. Other recent multilateral initiatives have stressed the importance of improving nuclear material accounting practices and added impetus to states' efforts to improve the national systems they have in place to respond to IAEA or national-level requirements. For instance, the Global Initiative to Combat Nuclear Terrorism's statement of principles exhorts participants to "develop, if necessary, and improve accounting, control and physical protection systems for nuclear and other radioactive materials and substances"; the communiqué of the inaugural Nuclear Security Summit in 2010 emphasizes the need for states to "promote measures to secure, account for, and consolidate these [highly enriched uranium and plutonium]"; and the NPT 2010 Review Conference final document commits the nuclear weapons states to begin regular discussions about ways to accelerate concrete progress on steps leading to nuclear disarmament, including measures that address all nuclear weapons regardless of their type or location, that reduce current nuclear risks, and that enhance transparency and increase mutual confidence.

Nuclear Cooperation Agreements. For economic, diplomatic, and security reasons, a number of states have negotiated nuclear cooperation agreements with other states or supranational entities to facilitate the transfer of sensitive nuclear technologies and nuclear materials. (As one of the largest of the nuclear supplier nations, the United States has negotiated at least 25 of these agreements.) The Nuclear Suppliers Group, a group of 46 nations that have the capability to produce and export sensitive nuclear technologies and materials, insists that its participants only supply materials to states that have IAEA Safeguards Agreements, which include requirements for the accounting of materials that are imported and exported. In addition, individual nuclear cooperation agreements typically obligate recipient nations to maintain material accounting records for transferred materials and to regularly report to the supplier nations on changes to material inventories.[4]

The Nuclear Suppliers Group has been attempting to negotiate broader guidelines for its members, to include requiring recipient states to sign an Additional Protocol with the IAEA, but these broader guidelines have yet to be approved. Were the Additional Protocol added to the list of recipient state requirements, states would have added incentives to adopt an Additional Protocol (if they haven't already), and the IAEA would then have assured access to more detailed material accounting data than it currently does.

Cooperative Threat Reduction initiatives. As part of its effort to reduce the nuclear proliferation risks from Russia and the states of the former Soviet Union, the United States engaged in a broad program of cooperative threat reduction starting in the early 1990s. As part of the many initiatives that have come to

[3] UN member states are required to submit to the 1540 Committee a matrix that documents their progress in implementing the resolution. The section of the matrix most relevant to nuclear material accounting practices is "OP3 (a) and (b)." The most recent approved 1540 matrices are available at: http://www.un.org/sc/1540/approvedmatrices.shtml

[4] For instance, Article XI (B)(2)(c)(i) of the 1974 nuclear cooperation agreement between the United States and the Republic of Korea requires the "maintenance and production of operating records" and the transfer of "reports for the purpose of assisting in ensuring accountability for such materials."

be under the cooperative threat reduction umbrella, the United States has worked to consolidate and relocate nuclear materials, increase the physical protection of remaining materials, and introduce more modern nuclear material accounting systems and practices. The most prominent example of U.S. work to improve nuclear material accounting practices is in Russia, where U.S. officials worked with Russian officials to develop a state-wide material accounting system for civilian-controlled nuclear materials that corresponds to international best practices (see later sections).

Though not formally part of cooperative threat reduction activities, many states, including the nuclear weapons states, have launched programs to work independently and in coordination with the IAEA to train and to otherwise make available their expertise to other states looking to improve their nuclear material accounting systems.

State-level accounting system adaptations

States have adapted their nuclear material accounting systems in response to some or all of the policy initiatives listed above. In some cases it is not possible to trace particular changes to specific initiatives, however, overall trends in accounting practices correspond to the general expansion of accounting requirements (to include more quantities and types of materials, throughout more parts of their lifetime of use) and the desire for more integrated and accessible accounting information. The examples highlighted below illustrate some of the ways that both non-nuclear weapon states and nuclear weapon states have adapted their material accounting practices.

Canada. Canada was an early adopter of a Safeguards Agreement and an Additional Protocol, and is home to an array of nuclear fuel cycle facilities and reactors. As such, Canada's nuclear material accounting practices provide a relevant marker for non-nuclear weapon states. In June 2010, the Canadian Nuclear Safety Commission released regulatory document RD-336, "Accounting and Reporting of Nuclear Material," which updated its accounting and reporting requirements for specified nuclear materials. The new regulations resulted from years of research and public consultation that were launched in response to Canada's adoption of the Additional Protocol and the passage of U.N. Security Council Resolution 1540 and replaced regulations that had previously dictated nuclear material reporting requirements.

The new regulation maintains the standard arrangement of material balance areas, and continues to require facilities with nuclear materials to track and report changes to material inventory, the transfer of materials to and from other facilities, corrections to material balances, etc. It also formalizes changes to safeguards practices that were instituted as a consequence of the Additional Protocol. For instance, the regulations require quantities of enriched uranium and plutonium to be accounted for down to the gram of material, while uranium and thorium concentrates, natural uranium and thorium, and depleted uranium need to be reported only to the closest kilogram. The regulation doesn't include any reporting requirements specifically aimed at intermediate- or high-level wastes that contain uranium or plutonium.

Euratom. Euratom became the first, and so far only, supranational body to sign and put into force the Additional Protocol. In December 2005, a little more than a year and a half after its protocol went into force, the European Commission released revised guidelines for the application of Euratom safeguards

(formally known as Regulation No. 302/2005), which affected the functioning of the nuclear material accounting systems of European Commission members, including the nuclear weapons states of France and Britain. Among its changes, the new regulation stipulates that material accounting records need to include sufficient information (precise quantities of materials, inventory changes, as well as particular details—the category, obligation, and type—of those changes) so that any facilities' book inventory can be established at *any* time. The commission also continues to push the adoption of its ENMAS and ENMAS Light accounting systems in order to standardize accounting practices across Europe.

In response to the new guidelines, the Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France's nuclear regulatory authority, developed a material accounting software package that allows European Commission members to maintain an accounting system and generate accounting reports to meet Euratom requirements based on the data in their national material accounting systems. By improving the capability of European states to fulfill Euratom reporting requirements, IRSN is simultaneously improving those states' abilities to fulfill their independent IAEA obligations, including their obligations under the Additional Protocol.

United States. Like all other NPT-designated nuclear weapons states, the United States maintains only a voluntary Safeguards Agreement with the IAEA, and only a fraction of the materials held in U.S. facilities are subject to IAEA reporting requirements. Yet, the United States maintains extensive facility-level and national-level nuclear material accounting systems in order to fulfill a range of other domestic and international commitments. For instance, these systems play an important role in fulfilling those few IAEA reporting requirements that exist; in meeting obligations to report information about foreign nuclear materials that are in use or processed in U.S. facilities; in ensuring that dangerous nuclear materials aren't diverted from domestic facilities; and in efficiently managing the flow of nuclear materials from one facility to another.

As part of the U.S. Additional Protocol, which entered into force in 2009, the United States submitted several additional research institutions to the list of facilities eligible for strengthened safeguards, to include providing reports that include the quantity, uses, and location of specific nuclear materials at those facilities.[5] U.S. facility-level nuclear material accounting systems are capable of accommodating increased IAEA reporting requirements. Yet, the real potential impact of the U.S. Additional Protocol is that it "establishes a mechanism that allows for continually deepening the breadth and scope of declarations in the future."[6] In other words, it creates the political space for the U.S. to increase the quantity and type of it declarations.

In order to meet more stringent domestic accounting requirements, several U.S. facilities have supplemented their nuclear material accounting practices as part of the Safeguards First Practices Initiative, to include both process and item monitoring. Process monitoring relies on carefully documenting and comparing the measurements of materials and reagents used to process nuclear materials at specific points during a task in order to detect abnormal operation. Item monitoring ensures

[5] Eva C. Uribe et al., "A Comparison of the Additional Protocols of the Five Nuclear Weapon States and the Ensuing Safeguards Benefits to International Nonproliferation Efforts," INMM 50th Annual Meeting, Tuscon AZ, July 12-16, 2009.
[6] Ibid.

that the sample of materials that are used to verify material records each inventory period are in the prescribed location, that each item has the correct tamper-indicating device attached, and that there are no signs of tampering.

The United States is sharing some of its nuclear material accounting best practices with other states and helping them and the IAEA define what constitutes a "model" SSAC within the context of recent policy initiatives. As part of this effort, in April 2011, the IAEA hosted a training session for safeguards professionals from around the world at Oak Ridge National Laboratory. Part of a series of safeguard training sessions that the United States has been involved with for decades, this latest training session addressed a range of basic material accounting practices, and also worked to introduce foreign safeguards officials to more advanced accounting and monitoring methods, such as process and item monitoring, and technologies that would provide officials with greater continuity of knowledge about nuclear materials.

Despite helping other nations to improve their material accounting systems and practices, not all U.S. facilities with nuclear materials have advanced accounting practices in place, and the national system, the Nuclear Material Management and Safeguards System (NMMSS), relies entirely on facility-level systems to provide detailed, accurate accounting data in a timely fashion. The approximately 500 facilities that report material accounting data to NMMSS include varying levels of detail that leave significant gaps in what U.S. officials know and can report about U.S. materials. Facilities often submit their material accounting data in summarized form, which lacks details about discrete items; data submitted to NMMSS doesn't always distinguish between what material is in which material balance area within a facility; it doesn't always accurately reflect the location of in-transit materials; and changes in inventory aren't always reported in a timely fashion.[7]

NMMSS includes some information about the nuclear materials that are part of the U.S. nuclear weapons complex and are deployed at Department of Defense facilities, but this information is provided in aggregate form and falls well short of the item-level accounting implemented at some Department of Energy facilities.

Russia. As part of cooperative threat reduction efforts, Russia began developing its first national-level nuclear material accounting system in the mid 1990s. Based on the NMMSS, Russia's Federal Information System (FIS) effectively serves as Russia's SSAC, overseeing activities at civilian nuclear material facilities, tracking nuclear material transfers, accounting for foreign-owned material, fulfilling reporting obligations to the IAEA and as part of other international agreements, etc.[8] By 2002, all civilian facilities with nuclear materials began reporting their book inventories to the FIS, and starting in 2003, these facilities began reporting changes to those inventories on a quarterly basis.

[7] Department of Energy, "Nuclear Materials Management and Safeguards System: User Guide," Release 1.0, Version 1, October 2008; Christopher A. Aas et al., "Defense Nuclear Material Stewardship Integrated Inventory Information Management System (IIIMS)," Sandia National Laboratories, SAND2005-5688, November 2004; and interviews with Department of Energy officials.

[8] Rusty Babcock, "U.S. and Russian Cooperation on the Russian Federal Information System (FIS)," Presentation to NMMSS Users Annual Training Meeting, May 23-25, 2006.

Though Russia's Additional Protocol entered into force in 2007, it excludes many provisions of the model protocol and is unlikely to place many new demands on its fledgling nuclear material accounting systems. The one exception regards reporting about the transfers of nuclear materials and collaborations with non-nuclear weapons states. To fulfill these requirements will ostensibly require Russia to rely on the FIS and other facility-level accounting systems.

China. The Chinese Atomic Energy Agency's Office of Nuclear Material Control maintains an SSAC for civilian Chinese facilities that have nuclear material holdings, including reactors and some fuel cycle facilities. This national-level system relies on facility-level reporting, which varies depending on facility-level capabilities. In the past decade, China has improved many of its facility-level systems by adopting international material accounting standards and reporting processes.[9]

In addition, China adopted an Additional Protocol to its voluntary Safeguards Agreement in 2002. But much like Russia, China excluded many provisions of the model protocol, including those provisions relating to material accounting. China also limited the provision of information under its Additional Protocol to information related to the transfer of nuclear materials to non-nuclear weapons states, information that is already captured in the IAEA's system by those states' reporting requirements.[10]

Potential material accounting demands

As much as recent policy initiatives have affected nuclear material accounting practices, these changes represent incremental shifts in accounting standards and technologies, many of which were devised decades ago. Future policy initiatives are likely to require more fundamental changes.

As states with commercial nuclear reactors expand their capacities and others introduce nuclear reactors into their national energy systems, international commerce in nuclear materials and technologies is likely to expand, increasing the number of obligations that need to be tracked. Similarly, international agreements and policy initiatives could dramatically affect the structure of states' nuclear fuel cycles, concentrating the number and location of enrichment, fuel-fabrication, and fuel-processing facilities. Conversely, the designs of deployed reactors and the types of fuel used could increase the number of reactors sites and facilities at which material accounting is needed and/or make it harder to reliably account for materials and verify reporting. Future agreements to restrict the number of nuclear weapons that designated nuclear weapon states retain and/or to ban the production of fissile materials could also require these states to better integrate their civilian and military material accounting systems and share accounting data more widely, so as to provide assurances that nuclear materials aren't diverted to weapons production.

Nuclear energy growth. Conservative IAEA projections expect that by 2030, at least 10 countries that don't currently operate commercial nuclear power reactors could have their first reactor in operation. The

[9] For an overview of Chinese material accounting practices, see Nathan Busch, "China's Fissile Material Protection, Control, and Accounting: The Case for Renewed Collaboration," *The Nonproliferation Review*, Fall-Winter 2002; see also, Yun Zhou, "The Security Implications of China's Nuclear Energy Expansion," *The Nonproliferation Review*, July 2010.

[10] Uribe et al., "A Comparison of the Additional Protocols of the Five Nuclear Weapon States."

agency's high-end estimate is 25 new countries.[11] In addition to their reactor facilities, some, but not all, of these countries are planning to build fuel cycle facilities to support reactor operations, and some might even develop domestic uranium enrichment facilities and/or spent fuel reprocessing facilities. At the very least, not all of these countries are expected to foreswear the possibility of operating both front-end and back-end fuel cycle facilities.

During this same period, states that currently have commercial nuclear industries are expected to increase their total number of operating reactors, despite expected retirements. In total, low-end IAEA projections suggest that global nuclear generating capacity could grow from 372 GW(e) to 511 GW(e) by 2030. To significantly affect the impact of global climate change, this growth would need to be even greater, though this is admittedly unlikely under current conditions.[12] All of these new facilities and all of the nuclear materials that will be used in reactor operations will require detailed material accounting for one reason or another. In countries that don't operate fuel-cycle facilities, the need to meet reporting obligations to supplier states will be particularly acute. What options will these states have to streamline material accounting practices, while complying with commercial and security commitments?

Fuel-cycle changes. Along with the overall growth in global nuclear energy capacity and the number of facilities that maintain nuclear materials, changes in national nuclear fuel cycle policies could significantly affect material accounting practices. If the use of international nuclear banks or multi-lateral fuel-cycle facilities gains traction, then it is conceivable that the number of fuel-processing facilities and enrichment facilities would shrink, even if the total capacity to produce fresh nuclear fuel and nuclear targets increases. This in turn might lessen the burden on national nuclear material accounting systems and ease the verification of material inventories.

Conversely**,** as the commerce in nuclear materials and technologies grows, tracking nuclear material obligations is likely to become more complex and more important. It will be even more essential to have continuous, detailed material accounting to ensure that supplier nations know that materials are only being used for approved uses. It could also force nuclear weapons states to standardize the accounting of materials transferred between them. These changes could also have implications for identifying the source of nuclear materials if they are diverted or used in weapons or radiological dispersion devices. In other words who is the source of a material and who is responsible for its security if it has passed through many countries' care over the course of its lifetime?

Nuclear weapons reductions. By virtue of nuclear nonproliferation and arms control agreements, most states with nuclear weapons are reducing their weapons stockpiles or at the very least not expanding them. Those states that are expanding their nuclear weapons stockpiles or their capacity to produce weapon-grade material maintain significantly smaller stockpiles of weapons than the United States and Russia. For these reasons, recent nuclear arms control negotiations have focused on the two former Cold War adversaries.

[11] "International Status and Prospects of Nuclear Power, 2010," International Atomic Energy Agency, Vienna, 2011, p. 23.

[12] Steven Fetter and Tim Gulden, "Decarbonizing the Global Energy System: Implications for Energy Technology and Security," CISSM Working Paper, April 2005.

The recently ratified New START treaty offers modest weapons reductions and a continuation of much of the verification regime that had been put in place as part of earlier agreements, but no requirements to account for reserve warheads, spares, or those awaiting dismantlement—or the materials from dismantled warheads. Future arms control agreements are likely to address more, if not all, types of warheads in U.S. and Russian arsenals, which could require the innovative application of nuclear material accounting practices. For instance, just as past U.S-Russian arms control agreements aimed to provide for the exchange of enough information to reassure each side that the other was abiding by agreed limits on deployed weapons, future agreements and verification systems would need to provide reassurance that parties to an agreement are not recreating nuclear weapons out of material stockpiles.

The IAEA has proven adept at ensuring that non-nuclear weapons states don't divert their nuclear material stockpiles for use in nuclear weapons, but the strategic issues involved in ensuring that weapons states don't build weapons from their material stockpiles, while they still maintain weapon stockpiles and active weapon programs, are significantly different. For instance, how would Russian officials know that the nuclear materials from dismantled U.S. warheads aren't kept intact when they are transferred to civilian oversight, making it possible for the U.S. to quickly reconstitute these warheads? Even if the nuclear materials are machined or processed into agreed-upon formats, how would Russia be able to ensure that the United States doesn't remachine or reprocess the materials into weapons components?

One way to address some of these concerns would be for future nuclear reduction agreements to require states to exchange sufficient information about material management and accounting practices so as to ensure compliance with agreed upon limits and to give all parties involved the confidence that they could detect violations in a timely manner. Because all nuclear weapons states (including India, Pakistan, and Israel) would eventually need to be involved in broad nuclear weapons reductions, these countries will also expect and need to be able to provide reciprocal access to nuclear material accounting data.

Conclusion

This brief survey of likely future energy and security scenarios suggests that nuclear material accounting will become ever more central to the secure operation of nuclear reactors, the smooth global commerce in nuclear materials and technologies, as well as a reduction in the risks posed by assembled nuclear weapons and or materials that could be used to create weapons or sow terror. Though national- and facility-level material accounting systems and practices have been evolving in response to heightened concern about the risks posed by nuclear materials, as explicitly embodied in recent policy initiatives, their incremental change has not kept pace with the need for more in-depth, continuous material accounting information, across the complete range of material uses, including those materials in military stockpiles.

To fully meet present and emerging demands for accounting information, national officials and safeguards experts need to take a fresh look at material accounting practices and fundamentally reconceptualize the goals of material accounting and the capabilities of their attendant systems. The potential requirements outlined in the above scenarios can serve as a basis for this type of reformulation.