THE FUTURE OF NUCLEAR ENERGY TO 2030 AND ITS IMPLICATIONS FOR SAFETY, SECURITY AND NONPROLIFERATION

Part 3 – Nuclear Security

TREVOR FINDLAY

CIGI
The Centre for International Governance Innovation
Centre pour l'innovation dans la gouvernance internationale

Addressing International Governance Challenges

The Future of Nuclear Energy to 2030 and its Implications for Safety, Security and Nonproliferation

Part 3 – Nuclear Security

Trevor Findlay

CIGI's Nuclear Energy Futures Project is conducted in partnership with the Canadian Centre for Treaty Compliance (CCTC) at the Norman Paterson School of International Affairs, Carleton University, Ottawa. The project is chaired by CIGI Distinguished Fellow Louise Fréchette and directed by CIGI Senior Fellow Trevor Findlay, director of CCTC. CIGI gratefully acknowledges the Government of Ontario's contribution to this project.

Table of Contents

List of Tables and Figures

Technical Glossary

Units

BTU	British thermal unit
g	gram
kWh	kilowatt hour – a unit of electrical energy equal to the work done by one kilowatt acting for one hour
SWU	separative work unit – a measure of work done by a machine or plant in separating uranium into higher or lower fractions of U-235
t	tonne
We	watt (electric)
Wth	watt (thermal)

Elements and Compounds

C	carbon
CO2	carbon dioxide
Pu	plutonium
U	uranium
UF6	uranium hexafluoride

Metric Prefixes

k	kilo	10^3
M	mega	10^6
G	giga	10^9
T	tera	10^{12}

All dollar values in this report, unless otherwise noted, are in US dollars.

Foreword
By Louise Fréchette

2010 will be a pivotal year for nuclear issues. In April, President Obama will host a special summit on nuclear security. In May, parties to the Nuclear Non-proliferation Treaty will gather in New York for a review conference and in June, at the G8 Summit hosted by Canada, nuclear proliferation issues will occupy a prominent place on the agenda. New challenges to the nuclear nonproliferation regime by countries such as North Korea and Iran and growing concerns about the possible appropriation of nuclear material by terrorist groups arise at a time when there is much talk about a major increase in the use of nuclear energy for civilian purposes.

This so-called "nuclear renaissance" was the starting point of the Nuclear Energy Futures project which was initiated in May 2006. The purpose of this project was three-fold:

- to investigate the likely size, shape and nature of the purported nuclear energy revival to 2030 – not to make a judgement on the merits of nuclear energy, but rather to predict its future;
- to consider the implications for global governance in the areas of nuclear safety, security and nonproliferation; and
- to make recommendations to policy makers in Canada and abroad on ways to strengthen global governance in these areas.

The project commissioned more than a dozen research papers, most of which have been published in CIGI's *Nuclear Energy Futures Papers* series; held several workshops, consultations and interviews with key Canadian and foreign stakeholders, including industry, government, academia and non-governmental organizations; convened two international conferences, one in Sydney, Australia, and one in Waterloo, Ontario; and participated in conferences and workshops held by others. The project has assembled what is probably the most comprehensive and up-to-date information on possible additions to the list of countries that have nuclear power plants for civilian purposes. Along with this Survey of Emerging Nuclear Energy States (SENES), the project has produced a compendium of all the nuclear global governance instruments in existence today which will, I believe, prove to be a valuable reference tool for researchers and practioners alike.

The project was generously funded and supported by The Centre for International Governance Innovation and was carried out in partnership with the Canadian Centre for Treaty Compliance (CCTC) at Carleton University, Ottawa. I was very fortunate to have found in Dr. Trevor Findlay, director of the CCTC, the perfect person to oversee this ambitious project. I am very grateful to him and his small team of masters students at the Norman Paterson School of International Affairs, especially Justin Alger, Derek de Jong, Ray Froklage and Scott Lofquist-Morgan, for their hard work and dedication.

Nuclear issues are quintessential global issues. Their effective management requires the collaboration of a broad range of actors. Canada, with its special expertise in nuclear technology and its long history of engagement in the construction of effective global governance in this area, is particularly well placed to help deal with the new challenges on the horizon. My colleagues and I hope that the findings and recommendations of the Nuclear Energy Futures Project will be of use to policy makers as they prepare for the important meetings which will be held later this year.

Louise Fréchette
Chair of the Nuclear Energy Futures Project
Distinguished Fellow,
The Centre for International Governance Innovation

Preface to the Final Report of the Nuclear Energy Futures Project: Parts 1 to 4

This report culminates three-and-a-half years' work on the Nuclear Energy Futures (NEF) project. The project was funded and supported by The Centre for International Governance Innovation (CIGI) and carried out in partnership with the Canadian Centre for Treaty Compliance (CCTC) at Carleton University, Ottawa.

The purported "nuclear renaissance" was the starting point of the Nuclear Energy Futures project, which was initiated in May 2006. The purpose of this project was three-fold:

- to investigate the likely size, shape and nature of the purported nuclear energy revival to 2030 – not to make a judgment on the merits of nuclear energy, but rather to predict its future;
- to consider the implications for global governance in the areas of nuclear safety, security and nonproliferation; and
- to make recommendations to policy makers in Canada and abroad on ways to strengthen global governance in these areas.

Numerous outputs have been generated over the course of the study, including the Survey of Emerging Nuclear Energy States (SENES) online document, the GNEP Watch newsletter and the Nuclear Energy Futures papers series. The final installment from the project comprises six outputs: the Overview, an Action Plan, and a four-part main report. A description of how the project was conducted is included in the Acknowledgements section at the front of the Overview.

Part 1, The Future of Nuclear Energy to 2030, provides a detailed look at the renewed interest in global nuclear energy for civilian purposes. Growing concerns about energy security and climate change, coupled with increasing demand for electricity worldwide, have prompted many countries to explore the viability of nuclear energy. Existing nuclear states are already building nuclear reactors while some non-nuclear states are actively studying the possibility of joining the nuclear grid. While key drivers are spurring existing and aspiring nuclear states to develop nuclear energy, economic and other constraints are likely to limit a "revival." Part 1 discusses the drivers and challenges in detail.

Parts 2 through 4 of the main report consider, respectively, issues of nuclear safety, security and non-proliferation arising from civilian nuclear energy growth and the global governance implications.

Introduction To Parts 2 To 4: Implications of the Nuclear Revival

The implications for global nuclear governance of the less-than-dramatic nuclear revival projected by this report are not as alarming as they would be if a full-bore nuclear renaissance were on the horizon. Nonetheless, they are sufficiently serious to warrant attention now, especially as many aspects of the nuclear regime are today ineffective or under serious threat. Indeed, the slow pace of nuclear energy expansion gives the international community breathing space to put in place the necessary reform of global governance arrangements.

Parts 2 to 4 of the report will consider the implications of the nuclear revival — in the form predicted in Part one — for global governance in the key areas, respectively, of safety, security and weapons nonproliferation. Each section will:

1. Assess the current status of each issue area, including the existing global governance arrangements and their strengths and weaknesses;
2. Characterize the impact of the revival on the existing arrangements; and
3. Make recommendations for adapting the system so that it effectively and efficiently manages such change.

For the purposes of this report, "global nuclear governance" refers to the web of international treaties, agreements, regulatory regimes, organizations and agencies, monitoring and verification mechanisms and supplementary arrangements at the international, regional, sub-regional and bilateral levels that help determine the way that nuclear energy, in both its peaceful and military applications, is governed. Governance at these levels is in turn dependent on national implementation arrangements which ensure that each country fulfills its obligations in the nuclear field. Such a broad conceptualization of governance is intended to emphasize that a holistic approach is necessary when contemplating the implications of a civilian nuclear energy revival. Global governance will axiomatically be a collaborative enterprise involving many players. It will also be perpetually a work in progress. The NEF project has published a *Guide to Global Nuclear Governance: Safety, Security and Nonproliferation* which provides background to all of the governance elements considered here (Alger, 2008).

Although for the purposes of clarity this report treats nuclear safety, nuclear security and nuclear nonproliferation separately, there is a strong relationship among them that is not always reflected in the ad hoc evolution of the global governance regime pertaining to each. Nor is it often reflected in policy or academic analysis. In particular the nonproliferation community on the one hand, and the safety and security communities on the other, tend to ignore each other. Helping overcome this intellectual "stove-piping" is one of the secondary goals of this project.

The extent of the overlap between safety, security and nonproliferation is, however, increasingly recognized. Common principles, for instance, are seen to apply to safety and security, such as the philosophy of "defence in depth." As Richard Meserve points out with respect to nuclear power reactors, "The massive structures of reinforced concrete and steel … serve both safety and security objectives" (Meserve, 2009: 107). A major breach of physical security, such as sabotage of a nuclear power plant, could pose serious safety risks. Meserve also notes that occasionally plant features and operational practices driven by safety considerations conflict with those that

serve security purposes: "Access controls imposed for security reasons can inhibit safety, limiting access for emergency response or egress in the event of a fire or explosion" (Meserve, 2009: 107). Furthermore, safety and security measures designed to prevent unauthorized access to nuclear material can help prevent the acquisition of nuclear weapons by terrorists and other unauthorized entities. Again, nonproliferation measures, such as each country's State System of Accounting and Control (SSAC), designed to help verify non-diversion of nuclear material to weapons purposes, also serve to deter unauthorized activities such as illicit trafficking and help the state account for and thus protect its nuclear assets.

Fortunately there is growing official recognition of the close relationship among these three areas and a recognition that they have to be considered holistically if the global governance of all three is to be strengthened. The "3-Ss" concept — safeguards, safety and security — was adopted by the 2008 Independent Commission of Eminent Persons convened to make recommendations on the role of the IAEA to 2020 and beyond (IAEA, 2008d). It was later endorsed by the Group of 8 (G8) Summit in Hokkaido in 2008 as a means of raising awareness of the importance of integrating the three fields and strengthening "3-S" infrastructure through international cooperation and assistance (G8, 2008).

Part 3: Nuclear Security

Security affects the nuclear industry in a way that it does not affect other forms of energy generation. This is partly a legacy of the highly secretive nuclear weapons programs from which civilian applications of nuclear energy emerged. It is also due to the strategic nature of the facilities and nuclear materials involved. Large nuclear power plants or other facilities may make tempting targets for saboteurs, while nuclear materials may be purloined for use in nuclear or radiological weapons (also known as radiological dispersal devices or RDDs). Hence nuclear security is considered the exclusive preserve of sovereign states in a way that nuclear safety is not, making global governance in this area much more challenging. Since nuclear security and radiological protection measures necessarily involve key national functions such as law enforcement and control over access to information, states are "understandably reluctant to expose their sovereign security and law enforcement practices to external scrutiny, let alone anything resembling external regulation" (IAEA, 2003: 145). Moreover, as Matthew Bunn points out, "any test or assessment that revealed particularly urgent vulnerabilities would be especially closely held" (Bunn, 2009: 115). As the International Atomic Energy Agency (IAEA) judiciously puts it: "the responsibility for nuclear security rests entirely with individual States" (IAEA, 2006b: 1).

Another reason for the contrast in global governance in the safety and security domains, is that while safety has been amenable to quantitative probabilistic risk assessment, security threats are much more difficult to quantify because of "intelligent adversaries" and the paucity of data due to the few attacks on nuclear facilities that have occurred (Ferguson and Reed, 2009: 59). A further major difference is that safety culture, unlike security culture, "has evolved to become more open about admitting mistakes in a 'no fault' environment that should work to correct mistakes without seeking retribution on workers who have made mistakes or whistleblowers" (Ferguson and Reed, 2009: 59). Proposals for reforming global governance in the nuclear security arena clearly need to take these differences into consideration.

The Nuclear Security Threat

The issue of nuclear security has been thrust to the forefront of international concern by the terrorist attacks of September 11, 2001, even though those attacks had no nuclear component. The audacity of the international conspiracy that led to 9/11 has heightened awareness about two particular threats: the potentially catastrophic effects of a terrorist attack on a nuclear reactor or other nuclear facility, in effect using it as a radiological weapon; and, second, the possibility that a well-organized and well-funded group like Al Qaeda might seize nuclear material from the civilian nuclear fuel cycle for a nuclear weapon or RDD and might actually be able to use it for that purpose. Paradoxically it took a non-nuclear event like 9/11 to raise awareness about both types of threat without the world having to experience the nuclear security equivalent of Chernobyl.

Attacks on Nuclear Facilities

While attacks against well-guarded and fortified nuclear power plants might seem far-fetched, a Nuclear Policy Study Group speculated as early as 1977 that, "Terrorists

might choose the nuclear industry as a target to exploit the mystique that surrounds nuclear energy and nuclear weapons" (Keeney, 1977: 301). To date only minor incidents have occurred, but threats have been made against nuclear reactors in several countries, including Australia, Canada and the US. Such threats range from the purely symbolic to the deliberate attempt to cause a core meltdown and release of radioactivity. The 1977 Nuclear Policy Study Group concluded that while modern safety features reduce the likelihood of a major terrorist incident involving a civilian nuclear reactor, "defence-in-depth" strategies must not only take into account the chance coincidence of multiple malfunctions, but the "deliberate simultaneous sabotage of reinforcing safety measures" (Keeney, 1977: 307). Although, according to the Study Group it would require "technically sophisticated and knowledgeable commandos" to achieve a "high probability of causing a large radioactive release," this would not pose "an insuperable barrier to a group with time, resources, and determination." The report, now more than 30 years old, considered that a serious deterrent to terrorist attacks on nuclear facilities was the likelihood that the terrorists would die. Today suicide attacks are a commonplace terrorist tactic in certain parts of the world, magnifying the risk that they will be used against sensitive facilities like nuclear power plants.

Despite the rise in awareness that hijacked commercial aircraft are capable of being used as weapons, governments and reactor vendors appear confident that that nuclear reactors are physically capable of withstanding deliberate aircraft crashes. A report by the Electric Power Research Institute (EPRI) conducted at the request of the Nuclear Energy Institute (NEI) in 2002 concluded that structures that house reactor fuel at US nuclear power plants would protect against a release of radiation even if struck by a large commercial jetliner. According to the report, state-of-the-art computer modeling techniques determined that typical nuclear plant containment structures, used fuel storage pools, fuel storage containers, and used fuel transportation containers at US nuclear power plants would withstand these impact forces despite some concrete crushing and bent steel (EPRI, 2002).[1]

Following the 9/11 tragedy, the NRC initiated what it termed a "top to bottom" review of nuclear power reactor security. After much deliberation, in February 2009 the NRC issued a final rule that requires applicants for new power reactors to assess the ability of their reactor designs to avoid or mitigate the effects of a large commercial aircraft impact. "This is a common sense approach to address an issue raised by the tragic events of September 11, 2001," said NRC Chairman Dale Klein (NRC, 2009). The NRC required, in particular, strengthening of the design of the top part of a plant's outer shield building (Weil, 2009). Since NRC decisions are influential in setting standards for other countries, especially since most vendors wish to attract orders in the lucrative US market, such revamped policies may be adopted by others. Westinghouse, for instance, is seeking agreement for construction in China of an AP1000 design with airplane crash mitigation features that it has added since signing its contract with the Chinese (MacLachlan and Hibbs, 2009). It was anticipated that the Chinese would agree to the changes because Chinese firms included by Westinghouse in the AP1000 procurement chain would later reap the benefit of having a common basic design for all projects worldwide. This emphasizes the importance of and potential for international efforts to harmonize security regulations for new reactor designs through such mechanisms as the Multilateral Design Evaluation Program (see Part 2 of this report for details). It is not clear, though, to what extent existing nuclear reactors in all countries are capable of withstanding aircraft crashes and to what extent governments in general are taking steps to deal with the issue.

A related security threat to nuclear power installations is a deliberate military attack by a state. This issue is a longstanding one dating back to the Israeli attack on Iraq's Osirak reactor in 1981. It has resurfaced with another Israeli attack on an alleged nuclear reactor site in Syria in September 2007, as well as intimations for several years that Israel (and maybe even the US) was considering attacking Iran's nuclear facilities, including its nuclear power reactor at Bushehr. In the 1980s, attempts were made to include a ban on such attacks in a draft Radiological Weapons Convention (RWC) that was being negotiated in the Conference on Disarmament (CD), but this ended with the demise of the RWC negotiations themselves. Given the likelihood that Israel would not agree to a resumption of negotiations on this issue in the CD and the near certainty of failure of any talks that actually did manage to begin in other fora, this seems an unlikely candidate for extending global governance in the nuclear security area and will not be considered further in this report.

Seizure of Nuclear Materials

A second type of threat, the theft by terrorists of nuclear material for the purpose of making a nuclear weapon or RDD is considered one of the most significant current international security threats. Successfully stealing a significant amount of plutonium or highly enriched uranium (HEU) would certainly remove the greatest barrier faced by terrorists in achieving their goal of obtaining a nuclear weapon. Today, as Matthew Bunn notes, "Making a bomb does not take a Manhattan project: more than 90 percent of that 1940s-era effort was devoted to making the nuclear material, not making the bomb; and that was before the basic principles of nuclear bombs were widely known, as they are today" (Bunn, 2009: 113).

Theft from a standard nuclear power reactor is unlikely since the natural or low-enriched uranium used for fuel cannot be fashioned into a nuclear weapon. Theft of spent fuel is also unlikely since it is extremely radioactive and can be handled only with special equipment and shielding. The heavy casks (30-100 tons in the US) in which it is shipped further complicate theft. Reprocessing plants, along with breeder reactors, would be more likely to be targeted for the plutonium involved.

The real weak link in security is, however, the transportation of plutonium, another reason why widespread nuclear electricity generation using such material is inadvisable. Transport necessarily involves removing material from fixed, large-scale facilities with highly regularized security into environments, such as transport by road, rail and sea, where there is less predictability. (It should be noted, however, that since nuclear material in transport is mobile, it can also be removed from harm's way in a manner that material in a fixed location cannot be.) Terrorist targets during civilian nuclear transport could include:

- shipments of LEU from enrichment plants to fuel fabrication plants (the LEU might be seized for a radiological weapon);
- shipments of LEU or mixed-oxide (MOX) fuel from fuel fabrication plants to reactor sites; and
- shipments of plutonium from reprocessing plants to storage sites and fuel fabrication plants (Keeney, 1977: 304).

In May 2009, the NRC issued new US regulations to protect MOX fuel from theft or diversion, including a requirement that users of MOX with greater than 29 percent plutonium dioxide need "unique and separate approval from the Commission" (Weil, 2009: 2).

The easiest way of all for terrorists to seize HEU or plutonium is not, however, from civilian nuclear reactors, but from poorly guarded research reactors that use HEU or from ill-secured sites in the former

Soviet Union and elsewhere connected with past nuclear weapons programs.

These "legacy" issues are not the subject of this report, but are relevant to the reputation of the nuclear enterprise generally. Several projects have been underway since the collapse of the Soviet Union to deal with such challenges, notably the US Cooperative Threat Reduction (CTR) programs and the G8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction (Bunn, 2008; Global Partnership Program, 2007). In April 2009 in a speech in Prague, President Obama announced "a new international effort to secure all vulnerable nuclear material around the world within four years" (BBC News, 2009). This includes efforts to convert research reactors and other non-power generating reactors to low-enriched uranium. Obama also called for a Nuclear Security Summit, to be held in April 2010 in Washington, DC, to garner global support for such efforts and for improving nuclear security generally. The White House suggested that the summit "would allow discussion on the nature of the threat and develop steps that can be taken together to secure vulnerable materials, combat nuclear smuggling and deter, detect, and disrupt attempts at nuclear terrorism" (Horner, 2009). In September 2009, the UN Security Council, chaired by Obama, adopted Resolution 1887 that endorsed the goal of securing all insecure nuclear material and managing the use of HEU for civilian purposes (UN, 2009). Again, though, the focus of these efforts is likely to be nuclear weapons and existing nuclear materials, not the security of civilian nuclear power reactors. Paradoxically, once the legacy problems are resolved, the weakest link in nuclear security might be the civilian nuclear fuel cycle, unless this challenge is also addressed.

The Effects of 9/11

What Chernobyl did for nuclear safety, 9/11 has done for nuclear security. Since 9/11 there has been laudable action to strengthen the hitherto patchy international nuclear security regime for civilian nuclear energy. The most important step taken was amending the 1980 Convention on the Physical Protection of Nuclear Material to encompass nuclear material within national borders as well as in international transit. In addition, in April 2004 the UN Security Council adopted Resolution 1540, while in 2005 an International Convention for the Suppression of Acts of Nuclear Terrorism was adopted by the UN General Assembly. Both of these oblige all states to take national measures to prevent terrorists acquiring nuclear material and technology for weapons purposes. The IAEA has also seized the Initiative in making nuclear security one of its priority tasks.

At the national level, increasing attention is being paid to "guns, guards and gates" as the primary means of achieving security at all types of nuclear installations. In May 2009, partly as a result of a security review after 9/11, the NRC issued updated requirements for US nuclear power reactors, the first major overhaul of US physical security provisions in 30 years (Weil, 2009). They must be implemented within a year. Additions include provisions on cyber security, safety/security interface reviews, video image recording equipment and uninterruptible backup power for detection and assessment equipment. With regard to aircraft attack, reactor licensees must have mitigation strategies and response procedures in place for such an event, which is considered to be a "beyond-design-basis event." The rule also requires licensees to have demonstrated capabilities to protect against the "design basis threat," which describes the general attributes of potential adversaries who might attempt acts of radiological sabotage or theft of special nuclear material. Again the NRC is often the leader in setting regulatory standards and will, it is hoped, be emulated by national regulators that have not yet moved to improve nuclear reactor and other nuclear security since 9/11.

Clearly, though, the global security of nuclear material and installations is only as good as its weakest link and requires sustained international attention. As the IAEA dryly recommends, "The increasingly global nature of nuclear commerce and cascading developments in fields as diverse as transport, communications and information technology make it essential that States follow international best practice in trying to limit threats directed at nuclear material and/or facilities" (IAEA, 2003: 145). The possibility of a nuclear revival, especially in countries with weak and corrupt governance, poor regulatory systems and "security culture" deficits, compounds the necessity of strengthening the international nuclear security regime.

The International Nuclear Security Regime

The international nuclear security regime is nowhere near as extensive, advanced or entrenched as the regime for nuclear safety. There are fewer treaties, a less widely accepted set of recommended security principles and practices, little collaboration between nuclear plant operators worldwide, as in the case of World Association of Nuclear Operators (WANO) for nuclear safety, practically no peer review and an abiding sense that nuclear security is too sensitive an issue to be subject to global governance. Russia is reportedly especially opposed to international "interference" in national nuclear safety (ICNND, 2009 117). As Roger Howsley puts it, "The pervasive secrecy surrounding nuclear security means that no global mechanism is in place to identify the worst security performers and help them come up to the level of the best performers" (Howsley, 2009: 204). Ferguson and Reed note that "While improvements in nuclear safety have built on more than 50 years of experience in the commercial nuclear industry, the standards of excellence emulated from other nuclear organizations, and the decades-long experience of the IAEA in developing nuclear safety standards, nuclear security has not received as much attention and resources from the communitarian perspective" (Ferguson and Reed, 2009: 59).

This section of the report considers the international nuclear security regime, outlining the existing treaties, mechanisms and assistance measures in place to commit, guide and help states to prevent, detect and respond to theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material. As in other areas, a key role is played by the IAEA, but other organizations are also involved. While the regime is less extensive and complex than that for nuclear safety, there is some overlap between the two that provides a degree of mutual reinforcement.

Convention on the Physical Protection of Nuclear Material

The 1980 Convention on the Physical Protection of Nuclear Material (CPPNM) was opened for signature in March 1980 and entered into force in 1987. As of January 2010 there were 142 state parties (as well as Euratom), and 45 signatories (IAEA, 2010). It is the only legally binding multilateral treaty relating to the physical protection of nuclear material.

The purpose of the CPPNM is to commit states to ensure that nuclear material for civilian purposes under their jurisdiction is protected during international transport. It does this in three ways. First, it establishes legally prescribed protective levels for nuclear material during such transport. Annex 1 of the treaty sets out three categories of protection in descending order from Category

I, requiring the highest level of protection, to Category III requiring the lowest. Second, it seeks criminalization by states of the theft of nuclear material. Third, it promotes international cooperation in prosecuting offences and responding in the event of a breach. The treaty does not apply to nuclear material for military purposes or radioactive sources.

The CPPNM contemplates two protection scenarios: material stored in preparation for or immediately after international transport; and during international transport itself. When being stored, Category III materials must be stored in an area with controlled access. Category II materials must be under constant surveillance by guards or electronic devices, surrounded by a physical barrier, with limited and controlled points of entry. Category I material must be stored in the same way as Category II, but with added levels of protection, including the most severely restricted access and close communication between surveillance personnel and response forces.

During international transport of Category II and III materials, special precautions must be taken, including prior arrangements among sender, receiver and carrier which outline the time, place and procedures for transferring responsibility for the shipment. The same considerations apply to Category I materials, but these must also be under constant surveillance by escorts in close communication with appropriate response forces. Parties are obliged not to permit export of nuclear material unless assured that it will be protected during transport at the prescribed levels. Parties are also obligated not to import nuclear material from a non-state party unless assured that the material will be protected during transport at the levels provided for in the convention. Additionally, parties are required not to allow the transit of nuclear material through their own territory unless it is so protected.

Each party must identify to all other parties, either directly or through the IAEA, a central national point of contact with responsibility for physical protection of nuclear material and for coordinating recovery and response operations in the event of a breach. If an incident occurs, parties are required to cooperate to the maximum feasible extent in the recovery and protection of nuclear material. Finally, parties are required to criminalize a host of activities that relate to the unlawful use, possession or other unauthorized means of obtaining nuclear material. To facilitate the conviction of an offender, parties are required to provide assistance, including evidence, to other parties. Each party is obliged to report to the treaty depositary, presumed to be the IAEA (although the convention does not make this clear), the laws and regulations it has adopted to implement the convention.

While the treaty contains provisions for review conferences every five years, these are aimed at assessing the implementation of the convention as a whole, not the compliance of individual parties. There is no peer review mechanism, as in the case of the Convention on Nuclear Safety, nor does the IAEA have any particular role beyond transmitting information about national contact points. Monitoring or verification of compliance is completely absent. There is the usual dispute resolution mechanism, involving referrals to the International Court of Justice (ICJ), but these relate to interpretation of the treaty, not non-compliance. However, the IAEA provides states, on request, with advisory, review and other services to help them, among other things, assess and improve their compliance with the CPPNM (see below for details).

Amendment to the Convention on the Physical Protection of Nuclear Material

Not long after the negotiation of the CPPNM, efforts were underway to strengthen the treaty, essentially because it did not require states to protect nuclear material while

in domestic use, storage or transport (unless transport crossed international water or airspace). Hence important aspects of the civilian nuclear industry were not covered by the convention. In 1998, a group of experts convened by the IAEA Director General to review all Agency programs recommended that consideration be given to revising the CPPNM to extend it to domestic use, storage and transport.

Negotiations on a CPPNM Amendment stretched over many years, but were formally concluded at a diplomatic conference held in Vienna in July 2005. Undoubtedly the endgame of the negotiations was stimulated by the nuclear "near miss" that some considered the events of 9/11 to have been. The Amendment created a legally binding regime requiring each state party to the CPPNM to establish and maintain an "appropriate physical protection regime" for nuclear material in use, storage and transport and for nuclear facilities anywhere under its jurisdiction. Such a national regime should be designed to prevent theft, establish a rapid response capacity to locate and recover missing or stolen nuclear material, protect against sabotage of nuclear material or nuclear facilities, and mitigate the consequences of any successful sabotage. Each party must embed the treaty in its legal system, establish a legislative and regulatory framework to govern physical protection, and designate a competent authority responsible for domestic implementation and a point of contact which should be imparted to all other parties and the IAEA.

The Amendment embodies 12 fundamental physical protection principles, including Principle A, which holds that "responsibility for the establishment, implementation and maintenance of a physical protection regime within a State rests entirely with that State" and Principle G, which determines that "The State's physical protection should be based on the State's current evaluation of the threat." Other principles include those relating to development and maintenance of a security culture, implementation of the "defence-in-depth" concept, and the need for quality assurance programs, contingency plans and confidentiality.

The Amendment to the CPPNM was adopted in July 2005. As of January 2010 there were 33 parties (IAEA, 2010). The Amendment is not yet in force, as this is contingent on ratification by two thirds of the original 112 state parties to the CPPNM. One reason why early entry into force is so desirable is that the IAEA can then begin linking its advisory and expert services to compliance with nuclear safety standards domestically as well as during international transport.

International Convention for the Suppression of Acts of Nuclear Terrorism

Recognition of the threat of nuclear terrorism clearly preceded 9/11, derived in large part from the recognized risk that terrorists or other unauthorized persons could obtain loosely secured fissionable material from the former Soviet nuclear programs. It was Russia, therefore, which took the initiative at the United Nations General Assembly to propose an international instrument on nuclear terrorism. An Ad Hoc Committee was established by the General Assembly in 1996 to begin discussions on conventions banning terrorist bombings and nuclear terrorism. In 1998, the Committee began negotiations on an International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT), based on a text proposed by Russia.

Agreement on the text was delayed for several years by the attempt of some states to include a ban on the use or threat of use of nuclear weapons by states in the treaty. Others argued that the convention should be focused on individual criminal responsibility for acts of terrorism and law enforcement. Ultimately the latter

view prevailed, the events of 9/11 providing a stark rationale and final impetus for wrapping up the drawn-out negotiations. The Convention was adopted by the General Assembly in April 2005, opened for signature in September 2005 and entered into force in July 2007. As of January 2010, there were 63 state parties and 115 signatories (UN, 2005).

ICSANT establishes a wide variety of offences in relation to nuclear terrorism. It is an offence for any individual to possess radioactive material with the intent to cause death, injury or damage to property or the environment or use radioactive material in such a way that risks such consequences. Threatening to undertake these acts also constitutes an offence, as does participating as an accomplice or directing others to undertake such acts. Each party is obliged to establish the offences within its domestic criminal law, ensuring that the penalties take into account the grave nature of nuclear terrorism.

ICSANT also obliges parties to cooperate in preventing acts of nuclear terrorism by exchanging information. Each party must establish jurisdiction over the offences if they are committed on its territory, on board a vessel or aircraft registered by it or when the offender is one of its nationals. ICSANT requires parties to either prosecute or extradite an offender and to provide significant legal assistance to each other in connection with criminal proceedings.

ICSANT applies to all nuclear materials and facilities, including those used in civilian nuclear power programs. In terms of international governance, although the treaty names the UN Secretary-General rather than the IAEA Director General as depositary and therefore it is not considered within the IAEA's "family" of treaties, the IAEA does assume several treaty functions. Notably, if a state seizes control of any radioactive material, devices or facilities following the commission of an offence, that party must ensure that they are held in accordance with IAEA nuclear safeguards and must "have regard" for IAEA "physical protection recommendations and health and safety standards."[2] In doing so, the state party may call on the assistance of the IAEA. In addition, a state party that seizes material, a device or a facility is obliged to inform the IAEA Director General "of the manner in which such an item was disposed of or retained."[3]

While a valuable addition to the nuclear security regime, ICSANT does not have any monitoring, verification or compliance provisions, nor does it have any system of peer review or accountability. The convention has no provision for review meetings, but simply enjoins the parties to consult one another on its implementation. Amendments may be approved by a specially convened meeting of parties.

African Nuclear Weapon-Free Zone Treaty

Unusually, there is one nuclear weapon-free zone treaty, the 1986 African Nuclear Weapon-Free Zone Treaty (ANWFZ), also known as the Treaty of Pelindaba, that contains provisions for ensuring the physical security of nuclear materials. (The 1985 Treaty of Rarotonga, which created a nuclear weapon-free zone in the South Pacific, bans nuclear dumping, as does the ANWFZ, but does not concern itself with nuclear safety or security.) The Treaty of Pelindaba was opened for signature in April 1996 and entered into force with its twenty-eighth ratification on July 15, 2009 (Broodryk and Stott, 2009). Geographically it covers the entire African continent.

Under Article 10 of the treaty, state parties are legally obliged to maintain the "highest standards of security and effective physical protection" of nuclear materials, facilities and equipment. Each party undertakes to apply measures of physical protection equivalent to those provided for in the CPPNM and IAEA security guidelines. The treaty also bans attacks on nuclear facilities, again the only NWFZ to contain this provision.

To facilitate compliance, the African Commission on Nuclear Energy (AFCONE) is supposed to be established after entry into force, although this has not yet occurred. AFCONE is intended to facilitate exchanges of information and arrange consultations between parties. Presumably this is applicable to the treaty's nuclear security requirements, along with its other obligations. The treaty also has a compliance mechanism that should, in theory, be applicable to its security requirements. If a party believes another party is in breach of its obligations, the complainant is obliged to bring the issue to the attention of the accused state. The alleged non-compliant party has 30 days to provide an explanation and resolve the matter, including through "technical visits" if agreed by the parties. If the dispute is unresolved, the complaint will be forwarded to AFCONE. On receiving a detailed inspection report from the IAEA indicating a breach, AFCONE is supposed to meet in extraordinary session and make recommendations to the party concerned and to the African Union (AU). If necessary, the AU may refer the matter to the United Nations Security Council. This is the most explicit compliance language applicable to nuclear security in any multilateral treaty and could prove a useful mechanism if African states, apart from South Africa, succeed in acquiring civilian nuclear energy. The member states of other NWFZs could be encouraged to emulate the African zone in its attention to nuclear security.

Security Council Resolution 1540

Adopted in April 2004 by the United Nations Security Council under Chapter VII of the UN Charter, which makes it legally binding, Resolution 1540 obliges all states to refrain from providing support or assistance to non-state actors seeking to acquire so-called weapons of mass destruction (WMD) — normally taken to mean nuclear and radiological, as well as chemical and biological, weapons.[4] The resolution also requires states to adopt and enforce appropriate and effective laws that prevent non-state actors acquiring WMD or related materials and technologies. The Security Council has extended the resolution twice, in 2006 (Resolution 1673) for two years and in 2008 (Resolution 1810) till 2011. In seeking better national measures to protect, inter alia, nuclear and radioactive materials, the Initiative is both a nuclear security and a nonproliferation measure.

With respect to nuclear material, the resolution requires all states to develop and maintain: measures to account for and secure such items; "appropriate and effective" physical protection measures; "appropriate and effective" border controls and law enforcement agencies; and national export and trans-shipment controls. Unfortunately, the Council did not prescribe the characteristics of the measures that states were required to adopt, nor did it define "appropriate" or "effective." All UN member states are required, however, to report to the Council on their compliance with the resolution.

To ensure implementation and facilitate compliance, the resolution established a 1540 Committee comprising Security Council members. So far the Committee's role has been to urge states to supply the reports, to review them and to call on states that have not answered questions adequately or have not yet submitted a report to do so (Bunn, 2007). Thus, implementation of Resolution 1540 has focused on compliance with the requirement by states to submit reports, rather than in implementing the substantive measures called for. Initially, the Committee was hampered by not having the support of a dedicated secretariat or technical experts like those furnished to the Counter-Terrorism Committee established by Security Council Resolution 1373 in 2001.[5] The 1540 Committee has belatedly acquired such support, including a 1540 Committee of Experts.

While the initial mandate of the Committee was to last only two years, universal implementation of the supposedly binding resolution has taken much longer than anticipated. Consequently, the Committee has had its mandate renewed when the resolution itself was renewed. By July 2008, four years after the passage of the initial resolution, only 155 UN member states had submitted a national report, while 37 had not yet done so (UN, 2008a: 6). In response to the Committee's request for new reports in 2007, just 103 states had responded and 102 of these subsequently provided additional information.

These figures in fact overstate compliance, since some of the reports submitted have been inadequate, ranging from the incomplete to the farcical. The most often cited example is Yemen's, submitted only after prompting by the Chair of the 1540 Committee. Just five lines long, it consisted of the statement that Yemen does not possess WMD. This is an especially problematic case given the prevalence of terrorist entities in Yemeni territory and its potential degradation into a failed state (Olberg, 2006; West, 2005). Notably, too, Yemen has announced its interest in acquiring nuclear energy and has unsuccessfully sought French assistance for that purpose.

A 2007 study by Princeton University's Woodrow Wilson School of Public and International Affairs concluded that no country is in full compliance with the resolution's nonproliferation requirements (Bristol, 2007: 10). Based on discussions with members of the Resolution 1540 Committee and support personnel, the authors observed that by some measures even countries considered leaders in nonproliferation efforts would be no more than 50 percent compliant (Bristol, 2007: 10). Many states lack sufficient capacity and expertise to effectively implement Resolution 1540. Sub-Saharan African countries, which are "little inclined to divert scarce resources for implementing nonproliferation obligations," face technical problems even in compiling a report on their intended steps towards implementation, much less carrying them out (Heupel, 2007: 6-7). Among the sub-Saharan states that have expressed interest in nuclear energy are Ghana, Kenya, Namibia, Nigeria, Senegal and Sudan.

A comprehensive review of the implementation of Resolution 1540 was released in December 2009 by the Stanley Foundation. Based also on intensive discussions among the 1540 Committee members, the 1540 Committee of Experts and representatives of regional and international organizations, it is being shared with the Security Council. The report concluded that "One of the most positive and noticeable developments of the past few years has been the growing acceptance of 1540 as a legitimate international security instrument" (Stanley Foundation, 2009: 2). But it also reaffirmed that implementation remains slow and uneven, "in part due to the incredible diversity of different national circumstances and the lack of rationalized machinery at the global level." It suggested that the overarching goal of the 1540 Committee should be to act as "matchmaker" between willing donors and states needing assistance in capacity building, especially in crafting legislation and regulations. Critically, it called on industry to become increasingly involved. One encouraging development is the extent to which regional and sub-regional organizations have begun playing a significant role in assisting in 1540 implementation (Scheinman, 2008).

The 1540 Committee has not yet asked the Security Council to order specific states that have not yet submitted a report to do so. Nor has it determined, given the limited resources available, precisely which

states and which types of proliferation controls should receive the highest priority, including prioritizing among nuclear, chemical and biological weapons, with their varying perceived risks (Bristol, 2007). The Committee has enlisted the help of the IAEA in recommending better protection of nuclear facilities and materials from theft and sabotage (Bunn, 2007), but technical assistance on such matters is available directly from the IAEA anyway for member states that request it.

Given the implementation challenges and the fact that Resolution 1540 is targeted at preventing non-state actors from acquiring any type of WMD — not just nuclear — it would be unwise, at least in the short term, to put too much store on this measure in dealing with the added challenges of a nuclear energy revival. The concern of the resolution is clearly with past and existing WMD materials and capabilities, not with future ones, although the legislative and regulatory improvements that it promotes are vital additions to the global nuclear security regime generally and will benefit civilian nuclear energy security in the long run.

Role of the International Atomic Energy Agency

As in other nuclear matters, the IAEA plays a critical role in helping implement the existing legal instruments concerning nuclear security, as well as advising and assisting states in fulfilling their international and national obligations regarding physical protection for both nuclear materials and nuclear facilities. In 2007 a review of the IAEA's security program chaired by Roger Howsley, currently inaugural director of the World Institute of Nuclear Security (WINS), concluded that "the IAEA security team is doing a fantastic job" (Howsley, 2009: 204). The Agency is aware of the security implications of a nuclear revival, noting that it "presents opportunities and challenges in designing and incorporating concepts of nuclear security at the earliest possible stage of development and aligning them with the principles of safety and safeguards" (IAEA, 2008d: 4). However, compared to its nuclear safety program, the Agency's nuclear security program is relatively small and underfunded (Ferguson and Reed, 2009: 59).

IAEA Nuclear Security Standards and Recommendations

Since 1972 the IAEA has issued non-binding but authoritative recommendations on the physical protection of nuclear material and nuclear facilities. These are updated periodically, most recently in 1998 (IAEA, 1998). They reflect, according to the IAEA *Handbook on Nuclear Law*, international consensus, procedures and definitions going beyond those in the CPPNM and its Annex 1 (IAEA, 2003: 146). They describe, inter alia (IAEA, 1998):

- elements of a state system for the physical protection of nuclear materials and nuclear facilities;
- requirements for physical protection against the unauthorized removal of nuclear material in use and storage;
- requirements for physical protection against the sabotage of nuclear facilities and against sabotage involving nuclear material during use, storage and transport; and
- requirements for the physical protection of nuclear material during transport.

In 2006 the Agency launched its Nuclear Security Series of documents, to assist states in establishing a coherent nuclear security infrastructure. They are structured in the same way as its documents on nuclear safety, with a similar three-level schema, presumably in an effort to encourage states to treat them the same way.

IAEA Nuclear Security Series

Fundamentals comprise the objectives, concepts and principles of nuclear security, providing the basis for security recommendations.

Recommendations present best practices that should be adopted by member states in the application of the Fundamentals.

Implementing Guides provide further elaboration of the Recommendations in broad areas and suggest measures for implementation.

Technical Guidance publications comprise:

- **Reference Manuals**, with detailed measures and/or guidance on how to apply the Implementing Guides in specific fields or activities
- **Training Guides**, covering the syllabus and/or manuals for IAEA nuclear security training courses; and
- **Service Guides**, which provide guidance on the conduct and scope of IAEA nuclear security advisory missions.

International experts assist the IAEA Secretariat in drafting these publications. For Nuclear Security Fundamentals, Recommendations and Implementing Guides, open-ended technical meetings are held by the Secretariat to allow member states and other international organizations to review draft texts. In addition, to ensure a high level of international review and consensus, the Secretariat submits the drafts for review to all member states for 120 days. Technical Guidance publications are also developed in close consultation with international experts. Technical meetings are not required for these, but may be conducted when considered necessary in order to elicit a broad range of views. The drafting and review process takes account of confidentiality considerations and according to the Agency "recognizes that nuclear security is inseparably linked with general and specific national security concerns" (IAEA, 2008b).

The implementing guides most relevant to the security of civilian nuclear facilities are:

Engineering Safety Aspects of the Protection of Nuclear Power Plants against Sabotage, which furnishes guidelines for evaluating the engineering safety aspects involved in protecting nuclear power plants against sabotage, including standoff attacks. The guide, released only in 2008, takes into account the existing robustness of structures, systems and components, and emphasizes aspects of sabotage protection that work synergistically with protection against extreme external occurrences, such as earthquakes, tornadoes and human induced events (such as aircraft crashes).

Nuclear Security Culture explains the basic concepts and elements of a nuclear security culture and how they relate to arrangements and policies for other aspects of nuclear security. It emphasizes that nuclear security is ultimately dependent on individuals — policy makers, regulators, managers, individual employees and, to a certain extent, members of the public.

Preventive and Protective Measures against Insider Threats offers general guidance for the competent authorities and operators on prevention and protection against insider threats (threats to nuclear facilities can involve outsiders, insiders, or both in collusion).

Security in the Transport of Radioactive Material provides guidance in implementing, maintaining or enhancing a nuclear security regime to protect radioactive material (including nuclear material) in transport, against theft,

sabotage or other malicious acts that could, if successful, have unacceptable radiological consequences.

Development, Use and Maintenance of the Design Basis Threat focuses on the use of a design basis threat (DBT) — an assessment of the attributes and characteristics of potential insider and/or external adversaries who might attempt a malicious act, such as unauthorized removal or sabotage. A DBT is used to design and evaluate a physical protection system for nuclear or other radioactive material or associated facilities. This publication is intended for decision makers in organizations with roles and responsibilities for the development, use and maintenance of a DBT.

In addition, in 1997 the IAEA published *Guidelines for the Management of Plutonium* that several members, including the nuclear weapon states, had agreed to follow. These are concerned with both safety and security. In accordance with these guidelines, annual statements of national holdings of civil unirradiated plutonium and of plutonium in spent civil reactor fuel are submitted to the IAEA (Goldblat, 2002: 114). (The details are covered in Part 2 of this report.)

IAEA Activities: Plans, Funds, Advisory Services and Missions

The IAEA seemingly offers an impressive array of assistance to states in the nuclear security arena, much of it grouped under its three-year plans. While developing states have, laudably, taken advantage of these, the Agency reports a low participation rate by developed countries, illustrating again the secretiveness that attends the nuclear security issue.

Three-Year Plan of Activities to Protect against Nuclear Terrorism

The plans are designed to improve the security of nuclear and radioactive material worldwide by assisting states in implementing effective national security measures. The priorities are to provide advice concerning the implementation of international agreements and guidelines, review and assess the needs of member states, provide them with support in implementing nuclear security recommendations, and facilitate outreach and information exchange. The IAEA's second Nuclear Security Plan 2006-2009 (the first was from 2002-2005) has just ended (IAEA, 2006b). A new one, covering 2010-2013, was adopted by the IAEA General Conference in September 2009 (IAEA, 2009c). According to the Agency, the program of three-year plans has achieved "sufficient maturity to evaluate its own accomplishments and shortcomings, set meaningful priorities and indicators of success, and take into consideration the evaluations and inputs of other interested stakeholders and groups, including donors to the Nuclear Security Fund" (IAEA, 2008d: 1).

Nuclear Security Fund

In the last couple of years the Nuclear Security Fund (NSF) has dispersed around $15-16 million annually in various nuclear security projects. Funding for the three-year plans comes from extra-budgetary donations by just a few states. In 2007-2008 pledges were received from the Czech Republic, Denmark, Finland, France, Japan, Spain, Sweden and the US (IAEA, 2008d: 20). Actual contributions were provided by the Czech Republic, Denmark, the European Community, Finland, France, Ireland, Japan, South Korea, Pakistan, Oman, Romania, Sweden and the US. Member states also provided "in-kind" contributions, such as donations of equipment, cost-free experts, the use of facilities and the hosting of meetings and training activities. A major new source of funding is the EU Strategy against Proliferation of Weapons of Mass Destruction (see below for details).

A major stumbling block to a more effective and efficient program is that 90 percent of the funds donated come with conditions. These are primarily limitations on the geographic location of the project for which funds can be used and/or the purposes to which they may be applied, as well as restrictions relating to procurements and human resources. The Agency notes, diplomatically, that such restrictions make "setting overall programmatic priorities difficult" (IAEA, 2008d: 2).

International Physical Protection Advisory Service

The International Physical Protection Advisory Service (IPPAS) is the IAEA's primary mechanism for evaluating a member state's physical protection arrangements. Its missions conduct detailed reviews of the legal and regulatory infrastructure of a requesting state and determine the level of compliance with the CPPNM. They also seek to compare national practice with IAEA standards and international best practice. The confidential mission reports are intended to form the basis for remedial action. As of October 2009, 46 IPPAS missions had been completed in 31 states (including follow-up missions in 10 states) in all regions (IAEA, 2008c; Gregorič, 2009). The IAEA provides follow-up assistance such as training, technical support and more targeted assessments.

International Nuclear Security Advisory Service

The International Nuclear Security Advisory Service (INSServ) conducts missions, at a state's request, to assist in identifying its nuclear security requirements and the ways in which it can fulfill them. It generates a report which can serve as the basis for cooperation between the state and the IAEA and for bilateral nuclear security assistance. The Agency reports that 29 INSServ missions had been conducted to June 30, 2008 (IAEA, 2008b).

International SSAC Advisory Service and International Team of Experts

The International SSAC Advisory Service (ISSAS) provides requesting states with recommendations regarding improvements to their State System of Accounting and Control (SSAC), the basis, since 1993, of the IAEA's strengthened safeguards system. The service contributes to safety and security by ensuring that states can adequately account for their nuclear material.

International Team of Experts (ITE) advisory missions may be dispatched to an IAEA member state at its request. The objectives of such missions are to inform national policy makers about the need for states to adhere to the international legal framework governing nuclear material and how to implement it domestically.

Integrated Regulatory Review Service

As noted in the nuclear safety section of this report, the Integrated Regulatory Review Service (IRRS) was inaugurated in 2006 to help states, at their request, to improve the effectiveness of national regulatory bodies and to assist in the implementation of national safety legislation and regulations. These reviews may benefit the nuclear security infrastructure by fostering more effective national regulators and better legislative frameworks. Between 2006-2009, the legislative assistance program of the Agency reviewed the national laws of 51 countries, more than half of which were African (IAEA, 2009e: 20). Among the states included in this project's Survey of Emerging Nuclear Energy States (SENES), that have received such assistance are: Algeria, Belarus, Chile, Egypt, Morocco, Thailand and Tunisia (IAEA, 2008d: 10).

Workshops and other forms of training included national workshops on nuclear law in Malawi and Nigeria and a workshop on nuclear safety, security and safeguards in Turkmenistan.

Integrated Nuclear Security Support Plans

The Integrated Nuclear Security Support Plan (INSSP), based on findings from nuclear security support missions, attempts to provide states, in contrast to the previous ad hoc approach, with a "holistic" approach to nuclear security capacity building. The plan is individualized to meet the needs of each state. From June 2007 to July 2008 the Agency developed six INSSPs in cooperation with state authorities in Brazil, China, Pakistan, Peru, Qatar and Saudi Arabia (the latter two are SENES states), bringing the total to 44 since the program began (IAEA, 2008d: 2 and 18).

Nuclear Security Support Centres

The IAEA has recently developed a conceptual approach for the establishment and maintenance of national Nuclear Security Support Centres to foster a "systematic, business-oriented approach" to nuclear security (IAEA, 2008d: 17). The centres will serve as a focal point for sustainable and continued access to knowledge, skills and abilities. It appears that none has yet been established (IAEA, 2009d).

IAEA Role in Dealing with Illicit Trafficking of Nuclear Materials

Illicit Trafficking Database

Established in 1995, the IAEA's Illicit Trafficking Database (ITDB) is designed to facilitate the exchange among states of authoritative information on reported incidents of illicit trafficking in all types of nuclear materials and radioactive sources. The ITDB covers unauthorized acquisition (for example, theft), supply, possession, use, transfer and disposal of nuclear and other radioactive materials, whether intentional or unintentional, and whether or not international borders were crossed. The ITDB also covers unsuccessful or thwarted acts, accidental loss of materials and the discovery of uncontrolled materials. All types of nuclear materials (uranium, plutonium and thorium), all naturally occurring and artificially produced radioisotopes, and radioactively contaminated materials are included. No limit is placed on the amount of material involved, its activity level or other technical characteristics. States are also encouraged to report scams in which non-radioactive materials are offered for sale as nuclear or radioactive materials.

At least in the early years of the ITDB, most initial information came from press reports rather than states. Currently, the ITDB collects information from 107 participating states (IAEA, 2008d: 1) but also from "non-participating states." States are not obliged to contribute, since the database does not derive from a treaty obligation or other international agreement. The ITDB still collects information from open sources, but seeks confirmation about its veracity from the member state concerned.

ITDB information is continuously analyzed by the Agency's staff to identify trends and patterns, assess threats and evaluate weaknesses in material security and detection capabilities and practices (IAEA, 2006a). The Secretariat produces quarterly and annual reports containing ITDB statistics and analysis. Participating states are also provided with regularly updated CD-ROM versions of the database. Communication with participating states is maintained through a network of national Points of Contact (POC). Meetings of the POCs are organized regularly to review the operation of the ITDB.

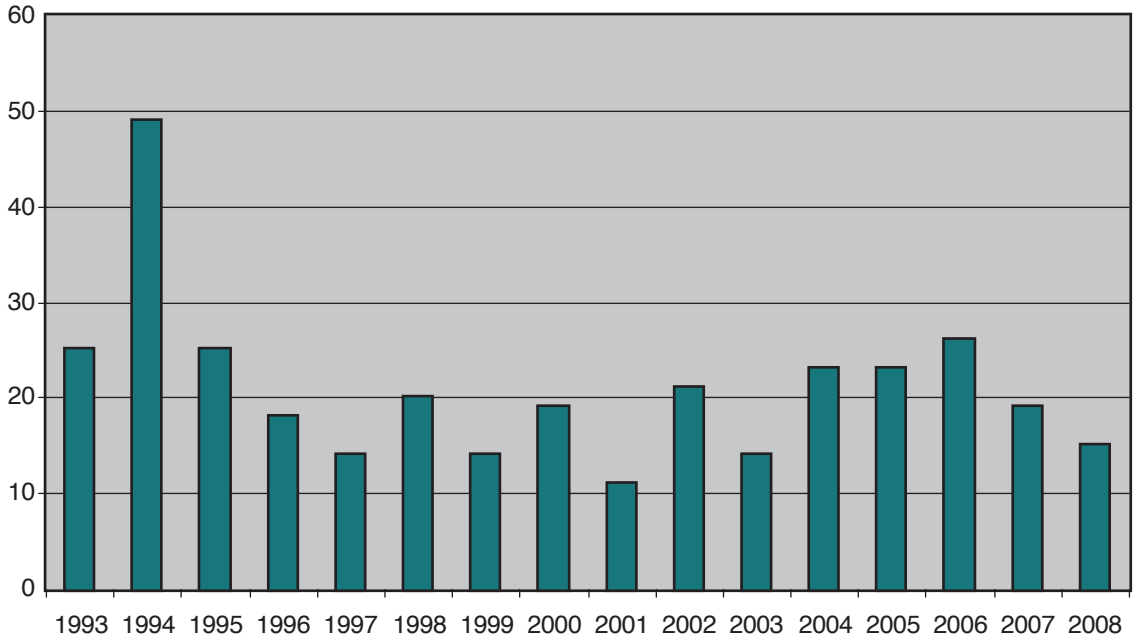
As of December 31, 2008, the most recent information available at the time of writing, the ITDB contained reports on 1,562 confirmed incidents as reported by participating states and some non-participating states. Of these, 336 involved unauthorized possession and related criminal activities, 421 involved reported theft or loss and 724 involved other unauthorized activities and events (IAEA, 2009a). In the remaining 81 cases the reported information was insufficient to determine the category of incident.

About 30 percent of all incidents involving unauthorized possession and related criminal activities occurred between 1993 and 1995. The number of cases reported annually subsequently declined and has been reasonably stable since then, with minor fluctuations, averaging about 19 incidents per year. Between 1993 and 2008, there were 15 confirmed incidents involving unauthorized possession of HEU and plutonium. Some of these involved attempts to sell the materials and smuggle them across national borders. A few involved seizures of kilogram quantities of weapons-usable nuclear material but mostly very small quantities. In some of these cases, however, there are indications that the seized material was only a sample of larger quantities available for illegal purchase or at risk of theft. These larger quantities have not been identified and recovered and, according to the IAEA, "pose potential security risk."

Again according to the Agency, incidents involving attempts to sell nuclear materials or radioactive sources indicate that there is a perceived demand for such materials on the illegal market. The majority of incidents have been supply-driven with no buyers. However, in some cases buyers and repeat offenders have been identified. Amateurishness and poor organization have characterized many trafficking cases, according to the IAEA, whereas well-organized, professional and demand-driven trafficking would be much more difficult to detect. Where information on motives is available, says the Agency, financial gain seems to be the principal motive. Some cases, however, showed an indication of malicious intent.

Clearly, one of the difficulties with this reporting instrument, as with others in the nuclear safety and security area, is that not all states provide reports and not all provide the requisite information when they do report.

Confirmed Incidents Involving Unauthorized Possession and Related Criminal Activities, 1993-2008



Source: IAEA (2009a)

Regional Meetings

Since July 2007, the IAEA has conducted eight regional information meetings for countries in Asia, Africa, the Middle East and Eastern Europe on illicit nuclear trafficking information management and coordination, in part to encourage participation in the ITDB. These are designed to help strengthen national, regional and international capacities by enhancing information- and knowledge-sharing, management and coordination; improving awareness of states about the ITDB program and enhancing reporting of incidents; foster regional dialogue; and promoting a culture of networking. Further meetings are planned for states in the remaining regions. These meetings are useful in educating and alerting states to the importance of the ITDB, but higher-level attention would help raise its profile. The Nuclear Security Summit in April 2010 would be an ideal occasion for this purpose.

Assistance to states

The IAEA continues to assist states to establish effective border monitoring capabilities. In 2008 it worked with 19 states, providing more than 260 items of equipment to improve detection and response capacities (IAEA, 2008d: 13). It also formed the Border Monitoring Working Group (BMWG) to promote and coordinate multilateral and bilateral cooperation in establishing detection monitoring capabilities at borders. The IAEA's Nuclear Security Equipment Laboratory (NSEL) helps ensure that border detection instruments meet technical and functional specifications. In November 2007, the Agency held an international conference on Illicit Nuclear Trafficking: Collective Experience and the Way Forward in Edinburgh, UK (IAEA, 2008d: 8).

Role of other organizations and initiatives

The Global Initiative to Combat Nuclear Terrorism

Jointly proposed by Russia and the US and launched in July 2006, the Global Initiative to Combat Nuclear Terrorism aims to increase international cooperation in combating nuclear terrorism. Since its inception in 2006, the Initiative has garnered the support of 76 countries for its statement of principles (US Department of State, 2009b). Participants commit themselves to develop partnerships to voluntarily implement measures that will improve the security of nuclear material and limit the ability of terrorists to acquire it. As of June 2009, partners in the Initiative have hosted more than 30 workshops, conferences and exercises (US Department of State, 2009a). The IAEA and EU participate as observers. The most recent plenary meeting of the Initiative in June 2009 reaffirmed its statement of principles and its commitment to increasing participation in key regions (US Department of State, 2009a).

While a useful addition to the expanding network of stakeholders in the nuclear security area, especially in bringing together the nonproliferation, counterproliferation and counter-terrorism communities, the Initiative has some drawbacks. It is far from universal, it has no standing institutional support, and up until 2009 it involved only governments. However, at their June 2009 meeting members agreed to admit the International Criminal Police Organization (INTERPOL) as an observer and to promote participation by civil society and business (US Department of State, 2009b). The impetus for the Initiative, like the Security Council

resolutions before it, is the possibility of terrorist threats involving nuclear weapons and existing nuclear materials, especially legacy materials from past weapons and civilian activities. It is thus not particularly attentive to the civilian nuclear power enterprise, although it could and should be extended to do so.

World Institute of Nuclear Security

The World Institute of Nuclear Security (WINS) is a new organization, based appropriately in Vienna, that has been jointly initiated by two US-based non-governmental organizations, the Nuclear Threat Initiative (NTI) and the Institute of Nuclear Materials Management (INMM), in cooperation with the US Department of Energy and the IAEA. It was launched at the IAEA's annual general conference in Vienna in September 2008. It is being supported financially by NTI and governments, to date Norway and the US.

WINS is dedicated to helping secure all nuclear and radioactive materials globally so that they cannot be used for terrorist purposes. Its mission is to provide an international forum for those accountable for nuclear security to share and promote the implementation of best practice. The organization promises to bring together nuclear security experts, the nuclear industry, governments and international organizations to focus on "rapid and sustainable" improvement of security at nuclear facilities globally. These security professionals, it notes, "are in the best position to know where the vulnerabilities are, how to improve security, and how to ensure that improvements are implemented quickly and effectively" (WINS, 2009). WINS assures its members that it will place a high priority on protecting sensitive information that may be discussed between them.

Currently, the size and nature of WINS' membership is unknown, although it is presently engaged in a membership drive. WINS has inaugurated a members' newsletter and released its first publication, a *Best Practice Guide on Security Culture*, "providing an easy to follow explanation of what culture is all about and specific questions to help you gauge what the culture is like in your organisation" (WINS, 2009).

According to WINS, its work will encompass both "weapons-usable material and radioactive materials," but its initial activities will concentrate on HEU and plutonium. The impetus for the creation of this organization has thus, yet again, come not from the use of civilian nuclear energy, but from concern about existing stocks of nuclear weapons materials, especially legacy materials in the former Soviet states, and civilian uses of HEU and plutonium, such as in research and isotope production reactors.

While the establishment of WINS fills a significant gap in the global governance regime for nuclear security, its relevance to civilian nuclear energy and hence to a nuclear revival remains to be seen. The task it has set itself with respect to existing weapons-grade materials is already daunting enough without tackling lesser security threats represented by an expansion of civilian nuclear energy. However, WINS' success in its chosen area of concern would pave the way for future attention to the security of the peaceful nuclear fuel cycle. Moreover, as it begins to instill observance of international security norms and expectations of a robust security culture in its member organizations, this may filter into all agencies concerned with nuclear security, including civilian plant operators.

European Union

The European Union (EU) Strategy against Proliferation of Weapons of Mass Destruction is partly devoted to nuclear security (IAEA, 2008d: 18). The EU has pursued a series of so-called Joint Actions since 2004 in support of the IAEA Nuclear Security Plan, providing substantial financial and

other contributions. The first Joint Action, from 2004-2007, was targeted at states in Southeastern Europe, Central Asia and the Caucasus. Currently, it is implementing its second Joint Action (2005), relating to North Africa and the Mediterranean states of the Middle East, and its third (2006), which covers all of Africa. In 2008 a fourth Joint Action was adopted relating to South-East Asia that will be implemented in 2009-2010. This program is thus covering many of the states seeking to acquire nuclear energy for the first time. The IAEA cooperates closely with the EU in implementing the program.

Compliance with and Implementation of the International Nuclear Security Regime

While IAEA standards and advisory services are vital, the global implementation of the highest levels of nuclear security is limited by the voluntary nature of the standards themselves and of the assistance provided. No current treaty provides the IAEA with the authority to insist on mandatory physical protection standards or other elements of nuclear security. Many states have long resisted such an approach. As in the nuclear safety area, there does appear to be increasing acceptance that the IAEA's standards are the international benchmark against which performance should be measured. In his background report for the work of the 2008 Commission of Eminent Persons on the Future of the Agency, then Director General ElBaradei suggested that by 2020 "many of the nuclear security documents will have become, de facto or de jure, international security standards and incorporated into national security policies and regulations" (IAEA, 2008a: 19). While this may happen, in the meantime states do not necessarily feel compelled to abide by them and some continue to treat them as merely recommendatory.

Effectively assessing national implementation of the treaty-based obligations in the area of nuclear security is also extremely difficult. There are no reporting or peer review requirements comparable to those found in either the Convention on Nuclear Safety or the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Nuclear Waste Management. Nor is there effective peer review of domestic physical protection systems by a nuclear industry body, as in the case of the World Association of Nuclear Operators for nuclear safety. As Roger Howsley notes, "building a sense of urgency and commitment to nuclear security within the nuclear industry" is a challenge (Howsley, 2009: 207). While employees in the industry "are trained to focus on safety from the first day of their careers," the same is apparently not true of security.

There is much less interest by states in taking advantage of the IAEA's nuclear security reviews compared to the safety realm, where demand threatens to overwhelm the Agency's capacity. Moreover, the nuclear security establishment, partly for understandable reasons, exhibits an even greater lack of openness and transparency than the nuclear safety community. Roger Howsley argues that nuclear security does not have to be as closed a topic as commonly imagined (Howsley, 2009: 207). He records that when he worked for British Nuclear Fuels Limited (BNFL) it conducted a national stakeholder dialogue from 1999 to 2005 that addressed many aspects of its operations though a nuclear security working group. The group, which included those with anti-nuclear views, was able to reach a consensus on around 60 recommendations, some of which BNFL adopted, improving security as a result. Howsley concludes that "Despite the profoundly different positions held by members of the group, this

provided clear evidence that properly facilitated meetings can be very productive and need not compromise security in any way." Canada's experience with wide-ranging community consultation to determine its nuclear waste policy, which also included security as one of its key objectives, was similar (NWMO, 2005: 194-201).

Internationally, Security Council Resolution 1540 and its reporting requirements, the only existing mechanism that provides any public record of implementation efforts in the nuclear security arena, are a step in the right direction. But reporting is only at a general level and does not focus on nuclear security specifically, much less the narrower area of the security of nuclear electricity generation and its associated fuel cycle activities. Moreover, the limited role currently being played by the IAEA in implementation of Resolution 1540 does not adequately capitalize on the Agency's strengths, resources and expertise, especially given the resource and capacity constraints faced by the 1540 Committee itself.

The most resounding problem facing the international nuclear security regime is that the Amendment to the CPPNM — the instrument that would create binding legal obligations to protect nuclear material in domestic use — has not drawn wide support, and consequently has not entered into force. When it does, the IAEA can at last begin to assess states' domestic nuclear security arrangements in the framework of compliance with the Amendment.

A joint endeavor by the IAEA and the 1540 Committee may represent the most feasible way to put in place verifiable nuclear security standards or at least physical protection standards (while not getting involved in sensitive matters like intelligence gathering and national threat assessments). The Security Council has the legal authority under Chapter VII of the UN Charter, while the IAEA has the organizational capacity and expertise to conduct inspections. George Bunn has suggested that the Security Council should establish effective global standards for physical protection of nuclear facilities and consider assigning the IAEA the task of conducting inspections to see whether these are being met (Bunn, 2007). It remains to be seen whether the developing countries would countenance further intrusion into their sovereign prerogatives by a Security Council that they accuse of "legislating" for them.

Implications of a Nuclear Energy Revival

Even if the nuclear energy revival is confined largely to the existing nuclear energy states, there will be growth in the numbers of nuclear reactors and fuel cycle facilities, more nuclear transport, both domestically and internationally, and more spent fuel and nuclear waste. Most of the existing nuclear energy states appear to have good security track records, since no significant incidents have occurred. But it is difficult for outsiders to assess their current and future capacities and hence how ready they are for any expansion in their nuclear energy sector. Awareness and preparedness seem to have increased since 9/11, but there are no public indicators of improvement as in the case of nuclear safety post-Chernobyl.

The nuclear weapon states have presumably extrapolated their experience in securing their nuclear weapon establishments to their civilian nuclear sectors, although this should not be taken for granted. Even in the nuclear weapon sector security incidents occur, as demonstrated in 2007 when the US Air Force temporarily "lost" several nuclear weapons on a flight from North Dakota to Louisiana (Starr, 2007). Nuclear security must therefore be a paramount concern in the expansion of nuclear

energy in existing states no matter how experienced they are. In 2007, the US Government Accountability Office recommended that the same security standards should be applied at commercial nuclear sites as at US nuclear weapon sites (GAO, 2007). The Nuclear Regulatory Commission (NRC) questioned this, arguing that security measures should take into account the type, form, purpose and quantity of materials (Fox, 2007a). There is, for instance, no separated plutonium at US civilian nuclear power plants.

The acquisition of reactors by states with a poor security track record and non-existent security culture would represent a significant challenge to the global nuclear security regime that it is currently ill-prepared to meet, especially with a true international security regime still in the process of emerging. Newcomers will take years — in some estimates at least five — to establish security infrastructure, systems and practices, and much longer to establish an acceptable security culture. Nigeria, for instance, is even now unable to provide security to its lucrative and decades-old oil industry. Increased numbers of nuclear power reactors and associated facilities may represent "high value" targets for secessionist movements, other rebel forces or terrorists. At the state level they may also be tempting targets in inter-state conflict, although neighbouring states may be deterred from attacking nuclear facilities given the possibility that they may also suffer the consequences of any release of radioactivity.

A number of SENES states are not party to the necessary nuclear security conventions (see chart), and the extent of compliance with them is in any event largely unknown publicly due to the lack of transparency in this field.

In the case of UN Security Council Resolution 1540, it is encouraging that all SENES states have submitted at least one report to the 1540 Committee. Only 20 of the SENES states have, however, submitted more than one report and only one, Algeria, has submitted an additional report in response to UN Security Council Resolution 1810 of April 25, 2008, which called for an update from each state.[6]

None of this engenders confidence in the ability of aspirant nuclear energy states to manage the security of nuclear facilities that they may acquire, especially since other deficits in physical and institutional infrastructure and governance, including corruption and mismanagement (as analyzed in the section of this report on nuclear safety), have implications for establishing effective nuclear security regimes. Thomas D'Agostino, head of the US National Nuclear Security Administration, has called for the international community to agree on a common set of security standards to ensure that a nuclear revival does not provide opportunities for terrorists or "rogue nations" to acquire sensitive materials: "We're already dealing with countries that have their own views on how they protect different quantities of what kinds of materials. Normalizing those and making sure we don't open some gaps in there is very important" (Schneidmiller, 2008). While such remarks seemed to ignore the IAEA's efforts at setting and implementing common standards, they do emphasize the distance still to go until harmonization is achieved. WINS could clearly play in important role in achieving this, in cooperation with the IAEA, in the same way that WANO does in the nuclear safety field. In respect of new reactor designs, the Multilateral Design Evaluation Program (MDEP) initiative should also be helpful in inculcating the concept of "security by design," in the same way that safety and safeguards are also to be considered part of the design process. Former NRC Chairman Dale Klein has called for MDEP to initiate "multilateral agreement" on "common threat parameters" that nuclear regulators apply worldwide for ensuring the security of nuclear power plants from "external aggression" (Klein, 2007).

Adherence to Nuclear Security Conventions by SENES States

State	Convention on the Physical Protection of Nuclear Material	Amendment to the Convention on the Physical Protection of Nuclear Material	International Convention for the Suppression of Acts of Nuclear Terrorism
Albania	In force		Signed
Algeria	In force	In force	
Bahrain			
Bangladesh	In force		In force
Belarus	In force		In force
Egypt			Signed
Ghana	In force		Signed
Indonesia	In force		
Iran			
Italy	In force		Signed
Jordan	In force	In force	Signed
Kazakhstan	In force		In force
Kenya	In force	In force	In force
Kuwait	In force		Signed
Libya	In force	In force	In force
Malaysia			Signed
Mongolia	In force		In force
Morocco	In force		Signed
Namibia	In force		
Nigeria	In force	In force	
Oman	In force		
Philippines	In force		Signed
Poland	In force	In force	Signed
Qatar	In force		Signed
Saudi Arabia	In force		In force
Senegal	In force		Signed
Syria			Signed
Thailand			Signed
Tunisia	In force		
Turkey	In force		Signed
United Arab Emirates	In force	In force	In force
Venezuela			
Vietnam			

Legend	
Unsigned	
Signed	
In force	

Source: IAEA (2010)

Conclusions

The international nuclear security regime, if it can even be so described, is not yet ready for any form of nuclear revival that goes much beyond existing nuclear energy states. As in the case of nuclear safety, many new entrants will lack the necessary security capability and experience, including the requisite legislative and regulatory framework, customs and border security, and enforcement capacity. States are even more secretive (often for understandable reasons) about nuclear security matters than they are about nuclear safety. International transparency is therefore constrained and IAEA involvement less welcome. The international conventions in this field are far from universal in adherence and application. Significant numbers of SENES states are not party to them. The Amendment to the Convention on the Physical Protection of Nuclear Material is not yet in force. And all of the nuclear security treaties, while legally binding in respect of their broad provisions, leave detailed implementation up to each state party. International verification of compliance and penalties for non-compliance are unknown.

The need for a certain level of secrecy in this field is a challenge to global governance. As the NEA notes, "There is an unavoidable tension between the need to communicate sufficient information to enable policymakers and the public to understand fundamental issues regarding nuclear technology, while protecting information that either contains commercially valuable proprietary information or that, if used in a malevolent manner, could pose additional risks to public health, safety and security" (OECD/NEA, 2008: 309). It recommends a "need to know" concept with two levels of disclosure: release of "generic" information on safety and security policies and practices to provide a measure of transparency, while limiting public release of specific information on facilities, transportation routes and other technical and operational details to avoid compromising security.

As in the case of nuclear safety, there needs to be greater cooperation among the various stakeholders involved in nuclear security. Due to the claimed sovereign prerogatives of states in this field, industry seems largely content to leave matters to governments, as it does in the case of nonproliferation. However, a major security incident at a nuclear power plant would threaten the nuclear revival in a similar fashion to a major nuclear reactor accident. In designing new generation reactors vendors need to consider security in the same way that they consider safety, while regulators need to consider how they will apply security regulations to new facilities.

There is thus a need to construct a true international, universal nuclear security regime that encompasses all interested parties — international organizations, governments and industry — since all are critical players in avoiding the adverse security implications that might arise from the spread of nuclear electricity generation capacities. The Fissile Materials Working Group has proposed a "Next Generation Nuclear Security Initiative" that would lay out a road map for nuclear security ahead of the April 2010 Nuclear Security Summit (FMWG, 2009). This should include nuclear security in respect of existing and future civilian nuclear facilities, not just legacy issues. Whether the summit leads to a truly global, participatory nuclear security regime, whether WINS or the Global Initiative to Combat Nuclear Terrorism are the kernel of such an effort, whether the IAEA itself takes up the challenge, or whether it needs to be constructed on a different basis, there is an urgent need for efforts to be made now before the nuclear revival is upon us.

Recommendations

- All states, but especially those seeking nuclear energy for the first time, should accede to the CPPNM and subsequently the Amendment when it enters into force; the Nuclear Suppliers Group should consider making such accession a condition of supply.
- The CPPNM Amendment should be brought into force in the near future, since it is the only legally binding instrument requiring the implementation of nuclear security at the national level; an active campaign should be mounted by the IAEA and supportive states to rally support to achieve entry-into-force.
- The 1540 Committee should "adopt objective criteria to help it identify countries and sectors where the implementation of particular proliferation controls is a high priority" and cooperate more closely with the IAEA in coordinating assistance to states experiencing difficulties in reporting and building capacity in the nuclear security area (Bristol, 2007: 18).
- The guidance and assistance provided bilaterally and multilaterally in the areas of security and safety should be increasingly integrated where appropriate, since they are increasingly interlinked (Meserve, 2009: 107).
- Adoption and implementation of IAEA nuclear security guidelines should be made a condition of IAEA assistance to states seeking to acquire nuclear energy; the Agency should seek the cooperation of the reactor supplier states and reactor and associated vendors in this endeavour.
- Governments and nuclear facility operators should support WINS by joining and providing it with substantive and financial assistance; WINS should seek to emulate the peer review system for nuclear safety by undertaking a pilot program to assess its feasibility.
- Member states of all nuclear weapon-free zones should seek to amend their founding treaties to add the need for compliance with IAEA nuclear safety and security standards and guidelines.
- Regional initiatives among likeminded states, such as in Southeast Asia and Latin America, should be pursued where they may have more immediate traction than global ones.
- States should provide increased funding to the regular IAEA budget that deals with nuclear security and to the Nuclear Security Fund; restrictions on NSF funding should be dropped.
- States should provide increased support for the IAEA's Incident and Emergency Centre, which is currently ill-equipped to cope with a major nuclear incident, whether from a safety or security perspective.
- The April 2010 Nuclear Security Summit should address the security of the civilian nuclear power sector and adopt measures specifically targeted at it, including where appropriate, those outlined above.
- Above all, a true global security community for the nuclear energy sector needs to be established involving all stakeholders — states, international organizations, regional organizations and, above all, the civilian nuclear industry itself.

Endnotes

1 The computer analyses, which cost more than $1 million, are summarized in EPRI, 2002.

2 Article 18.1.

3 Article 18.6.

4 For a detailed analysis see Bosch and Ham, 2007.

5 Currently known as the Counter-Terrorism Committee Executive Directorate (CTED).

6 On April 25, 2008, UN Security Council Resolution 1810 "encourage[d] all States that have submitted such reports to provide, at any time or upon the request of the 1540 Committee, additional information on their implementation of Resolution 1540" (UN, 2008b).

Works Cited

Alger, Justin (2008). "A Guide to Global Nuclear Governance: Safety, Security and Nonproliferation," *Nuclear Energy Futures Special Publication*. September.

BBC News (2009). "Obama promotes nuclear-free world." April 5. Available at: http://news.bbc.co.uk/2/hi/europe/7983963.stm.

Bristol, Joseph C., et al. (2007). "A New Urgency for Nonproliferation: Implementing United Nations Security Council Resolution 1540." Woodrow Wilson School of Public and International Affairs, Princeton University. January.

Bosch, Olivia and Peter van Ham (eds.) (2007). *Global Non-Proliferation and Counter-Terrorism: the Impact of UNSCR 1540*. London: Royal Institute of International Affairs.

Broodryk, Amelia and Noël Stott (2009). "Africa Is Now Officially a Zone Free of Nuclear Weapons." Arms Management Programme. Pretoria: Institute for Security Studies. August 12. Available at: http://www.iss.co.za/index.php?link_id=5&slink_id=8113&link_type=12&slink_type=12&tmpl_id=3.

Bunn, George (2007). "Enforcing International Standards: Protecting Nuclear Materials From Terrorists Post-9/11," *Arms Control Today.* January/February. Available at: http://www.armscontrol.org/act/2007_01-02/Bunn.

Bunn, Matthew (2009). "Reducing the greatest risks of nuclear theft & terrorism," *Daedalus*. Vol . 138, No. 4:112-123.

___ (2008). *Securing the Bomb 2008*. Managing the Atom Program, Belfer Center for Science and International Affairs. November 18. Boston: Harvard University.

Electric Power Research Institute (EPRI) (2002). *Deterring Terrorism: Aircraft Crash Impact Analyses Demonstrate Nuclear Power Plant's Structural Strength*. December. Available at: http://www.nei.org/filefolder/EPRI_Nuclear_Plant_Structural_Study_2002.pdf.

Global Partnership Program (2007). *2006-07 Annual Report on Canada's participation in the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction*. Ottawa: Department of Foreign Affairs and International Trade.

Goldblat, Jozef (2002). *Arms Control: the New Guide to Negotiations and Agreements*. London: Sage.

Gregoric, Miroslav (2009). "IAEA Activities in Nuclear Security." Department of Nuclear Safety and Security. October 7. Vienna: IAEA. Available at: http://www.iaea.or.at/OurWork/ST/NE/NEFW/CEG/documents/CEG_23/1-9%20IAEA%20Eng.pdf.

Heupel, Monika (2007). "Implementing UN Security Council Resolution 1540: A Division of Labor Strategy," *Carnegie Endowment for International Peace, Nonproliferation Program, No. 87*. Washington DC. June. Available at: http://www.carnegieendowment.org/files/cp87_heupel_final.pdf.

Horner, Daniel (2009). "Nuclear Security Summit Planned for March," *Arms Control Today*. September. Available at: http://www.armscontrol.org/act/2009_09/NuclearSummit.

Howsley, Roger (2009). "The World Institute for Nuclear Security: filling a gap in the global nuclear security regime," *Innovations*. Vol. 4, No.4: 203–208.

International Atomic Energy Agency (IAEA) (2010). "States' Participation in Major Agreements, Office of Legal Affairs." February 1. Available at: http://ola.iaea.org/lars/ReportOutput/GlobalReport.pdf.

___ (2009a). "ITDB Fact Sheet." Vienna. Available at: http://www-ns.iaea.org/downloads/security/itdb-fact-sheet-2009.pdf.

___ (2009b). "Nuclear Security Guidelines." Available at: http://www-ns.iaea.org/security/nuclear_security_series.htm.

___ (2009c). "Nuclear security, including measures to protect against nuclear and radiological terrorism." IAEA document GC(53)/RES/11. September.

___ (2009d). "President's Findings from the International Symposium on Nuclear Security." April 3. Available at: http://www-pub.iaea.org/mtcd/meetings/PDFplus/2009/cn166/cn166_SymposiumFinding.doc.

___ (2009e). "Implementation of the IAEA Nuclear Security Plan 2006–2009: Progress Report." IAEA document GOV/2009/53-GC(53)16. September 2009.

___ (2008a). "20/20 Vision for the Future: Background Report by the Director General for the Commission of Eminent Persons." IAEA document GOV/2008-GC(52)/INF/4, May.

___ (2008b). "International Nuclear Security Advisory Service." June 30. Available at: http://www-ns.iaea.org/security/insserv.htm.

___ (2008c). "International Physical Protection Advisory Service." June 30. Available at: http://www-ns.iaea.org/security/ippas.htm.

___ (2008d). "Nuclear security — measures to protect against nuclear terrorism," *Annual Report 2007*. IAEA document GC(52)/9. March.

___ (2006a). "ITDB Fact Sheet." Vienna. Available at: http://www.iaea.org/NewsCenter/Features/RadSources/PDF/fact_figures2006.pdf.

___ (2006b). "Nuclear security — measures to protect against nuclear terrorism," *Annual Report*. Director General, IAEA document GOV/2006/46-GC(50)/13. August 16.

___ (2003). Handbook on Nuclear Law, IAEA publication STI/PUB/1160. July.

___ (1998). "The Physical Protection of Nuclear Material and Nuclear Facilities." IAEA document INFCIRC/225/Rev. 4 (Corrected).

Keeny Jr., Spurgeon M. (Chairman) et al. (1977). "Nuclear Power Issues and Choices, Report of the Nuclear Energy Policy Study Group." Cambridge: Ballinger Publishing Company.

Meserve, Richard A. (2009) "The global nuclear safety regime," *Daedalus*. Vol. 143, No.4: 100–111.

NRC (2009). "NRC issues final rule on new reactor impact assessment." News Release. Washington, DC: US Nuclear Regulatory Commission. February 17.

OECD/NEA (2008). *Nuclear Energy Outlook 2008*. Nuclear Energy Agency, OECD.

Olberg, Lars (2006). "Implementing Resolution 1540: What the National Reports Indicate," *Disarmament Diplomacy,* No. 82. Spring.

Scheinman, Lawrence (ed.) (2008). *Implementing Resolution 1540: The Role of Regional Organizations*. New York: United Nations Institute for Disarmament Research.

Stanley Foundation (2009). "Implementing UNSCR 1540: next steps towards preventing WMD terrorism," *Policy Memo.* December 18. Available at: http://www.stanleyfoundation.org/publications/policy_memo/ImplementUNSCR15401209PM.pdf.

Starr, Barbara (2007). "Air Force investigates mistaken transport of nuclear warheads," *CNN*. September 6. Available at: http://www.cnn.com/2007/US/09/05/loose.nukes/index.html.

United Nations (UN) (2005). "International Convention for the Suppression of Acts of Nuclear Terrorism," *United Nations Treaty Series*. April 13. Available at: http://untreaty.un.org/cod/avl/ha/icsant/icsant.html

___ (2008a). "Report of the Committee established pursuant to Security Council Resolution 1540 (2004)." UN Security Council document S/2008/423. July 30.

___ (2008b). "Security Council Resolution 1810." UN document S/RES/1810. April 25.

___ (2009). "Security Council Resolution 1887." UN document S/RES/1887. September 24.

US Department of State (2009a). "Joint Co-Chair Statement at 2009 Plenary Meeting." Washington, DC: Bureau of International Security and Nonproliferation (ISN). June 16. Available at: http://www.state.gov/t/isn/rls/fs/125325.htm

___ (2009b). "The Global Initiative to Combat Nuclear Terrorism." Bureau of International Security and Nonproliferation (ISN). Available at: http://www.state.gov/t/isn/c18406.htm

World Institute for Nuclear Security (WINS) (2009). (website). Available at: http://www.wins.org

West, Deborah L. (2005). "Combating Terrorism in the Horn of Africa and Yemen," *World Peace Foundation, Report No. 40*. Cambridge, Mass.: John F. Kennedy School of Government, Harvard University.

About the Author

Dr. Trevor Findlay is a CIGI senior fellow and holder of the William and Jeanie Barton Chair in International Affairs and a professor at the Norman Paterson School of International Affairs at Carleton University, Ottawa, where he is also director of the Canadian Centre for Treaty Compliance.

From 1998 to early 2005, Dr. Findlay was executive director of the Verification Research, Training and Information Centre in London, UK. As an Australian diplomat, Dr. Findlay was a member of the Australian delegation to the Conference on Disarmament, the UN General Assembly and the UN Disarmament Commission. He was a senior fellow and acting head of the Peace Research Centre at the Australian National University before establishing the program on peacekeeping and regional security at the Stockholm International Peace Research Institute in Sweden. He is the author of several books, including Nuclear Dynamite: The Peaceful Nuclear Explosions Fiasco (Brassey's Australia, 1990) and The Use of Force in UN Peace Operations (Oxford University Press, 2002). He holds a BA Honours in political science from the University of Melbourne and a master's degree and PhD in international relations from the Australian National University.

Nuclear Energy Futures Project Publications

GNEP Watch: Developments in the Global Nuclear Energy Partnership
Miles A. Pomper, *#1 - #11*
October 2007 - December 2008

The Economics of Nuclear Power: Current Debates and Issues for Future Consideration
David McLellan, *Nuclear Energy Futures Paper #1*
February 2008

A Guide to Global Nuclear Governance: Safety, Security and Nonproliferation
Justin Alger, *Nuclear Energy Futures Special Publication*
September 2008

The Global Nuclear Safety and Security Regimes
Aaron Shull, *Nuclear Energy Futures Paper #2*
November 2008

The Russian Nuclear Industry: Status and Prospects
Miles A. Pomper, *Nuclear Energy Futures Paper #3*
January 2009

The British Nuclear Industry: Status and Prospects
Ian Davis, *Nuclear Energy Futures Paper #4*
January 2009

Survey of Emerging Nuclear Energy States
Ray Froklage et al., *Nuclear Energy Futures web-based document*
May 2009

Uranium Enrichment in Canada
David Jackson and Kenneth Dormuth, *Nuclear Energy Futures Paper #5*
May 2009

From Nuclear Energy to the Bomb: The Proliferation Potential of New Nuclear Programs
Justin Alger, *Nuclear Energy Futures Paper #6*
September 2009

The US Nuclear Industry: Current Status and Prospects under the Obama Administration
Sharon Squassoni, *Nuclear Energy Futures Paper #7*
November 2009

The Canadian Nuclear Industry: Status and Prospects
John Cadham, *Nuclear Energy Futures Paper #8*
November 2009

The Indian Nuclear Industry: Status and Prospects
M. V. Ramana, *Nuclear Energy Futures Paper #9*
December 2009

US International Nuclear Energy Policy: Change and Continuity
Miles A. Pomper, *Nuclear Energy Futures Paper #10*
January 2010

Nigeria and Nuclear Energy: Plans and Prospects
Nathaniel Lowbeer-Lewis, *Nuclear Energy Futures Paper #11*
January 2010

The Future of Nuclear Energy to 2030 and Its Implications for Safety, Security and Nonproliferation
Trevor Findlay, *Nuclear Energy Futures Project Report*
February 2010
Overview
Part 1 – The Future of Nuclear Energy to 2030
Part 2 – Nuclear Safety
Part 3 – Nuclear Security
Part 4 – Nuclear Nonproliferation

Nuclear Energy and Global Governance to 2030: An Action Plan
Louise Fréchette (chair), Trevor Findlay (director),
Nuclear Energy Futures Project Report
February 2010

Acronyms and Abbreviations

ABACC	Argentine-Brazilian Agency for Accounting and Control
ABWR	Advanced Boiling Water Reactor
ACR	Advanced CANDU Reactor
ADB	Asian Development Bank
AECL	Atomic Energy of Canada Limited
AFCI	Advanced Fuel Cycle Initiative (GNEP)
AFCONE	African Commission on Nuclear Energy
AFNI	L'Agence France Nucléaire International (France)
AIP	Advance Information Package (OSART)
ALARA	as low as reasonably achievable
ANDRA	Agence nationale pour la gestion des déchets radioactifs/ National Agency for the Management of Radioactive Waste (France)
ANWFZ	African Nuclear Weapon-Free Zone Treaty
AP	Additional Protocol (IAEA)
ASE	AtomsTroyExport (Russia)
ASME	American Society of Mechanical Engineers
ASN	Nuclear Safety Authority (France)
AU	African Union
BADEA	Arab Bank for Economic Development in Africa
BMWG	Border Monitoring Working Group (IAEA)
BNFL	British Nuclear Fuels Limited
BOG	Board of Governors (IAEA)
BSS	Basic Safety Standards (IAEA)
BWR	boiling water reactor
CACNARE	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
CANDU	Canada Deuterium Uranium reactor
CBO	Congressional Budget Office (US)
CCGT	combined cycle gas turbine
CCPNM	Convention on the Physical Protection of Nuclear Material
CCS	carbon capture and storage
CD	Conference on Disarmament (UN)
CDM	clean development mechanism
CEA	Commissariat à l'Énergie Atomique/ Atomic Energy Commission (France)
CEC	Commission of the European Communities (now EC)
CENNA	Convention on Early Notification of a Nuclear Accident
CFDT	Confédération Français Démocratique du Travail/ French Democratic Confederation of Workers
CHP	combined heat and power
CIA	Central Intelligence Agency (US)
CIRUS	Canada India Research US reactor
CISAC	Committee on International Security and Arms Control
CNRA	Committee on Nuclear Regulatory Activities (OECD/NEA)
CNS	Convention on Nuclear Safety
CNSC	Canadian Nuclear Safety Commission (Canada)
COGEMA	Compagnie Général des Matièrere nucléaire/ General Company for Nuclear Materials (France)
CORDEL	Working Group on Cooperation in Reactor Design Evaluation and Licensing (WNA)
CSA	Comprehensive Safeguards Agreement (IAEA)
CSS	Commission on Safety Standards (IAEA)
CTBT	Comprehensive Nuclear Test Ban Treaty
CTR	Cooperative Threat Reduction
DBT	design basis threat
DOE	Department of Energy (US)
DTI	Department of Trade and Industry (UK)
DUPIC	direct use of spent PWR fuel in CANDU
EC	European Commission
EDF	Electricité de France
EIA	Energy Information Agency (DOE)
ENAC	Early Notification and Assistance Conventions
ENATOM	Emergency Notification and Assistance Technical Operations Manual
ENEN	European Nuclear Education Network
ENSREG	European Nuclear Safety Regulators Group
EPAct	US Energy Policy Act (2005)
EPR	Evolutionary Power Reactor (formerly European Power Reactor)
EPREV	Emergency Preparedness Review Teams (IAEA)
EPRI	Electric Power Research Institute
ERBD	European Bank for Reconstruction and Development (EC)
ERNM	Emergency Response Network Manual
EUP	enriched uranium product
Euratom	European Atomic Energy Community (EC)
FAO	Food and Agricultural Organization of the United Nations
FBR	fast breeder reactor
FMCT	Fissile Material Cut-Off Treaty
FMT	Fissile Material Treaty
FOAK	first-of-a-kind
FP&L	Florida Power and Light
G8	Group of Eight
GAO	Government Accountability Office (US)
GCC	Gulf Cooperation Council
GCR	gas-cooled reactors
GDF	Gaz de France
GDP	gross domestic product
GHG	greenhouse gases
GIF	Generation IV International Forum
GNEP	Global Nuclear Energy Partnership
GPP	Global Partnership Program (G8)
GTCC	gas turbine combined cycle
HEU	highly enriched uranium
IACRNA	Inter-Agency Committee on Response to Nuclear Accidents
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICJ	International Court of Justice
ICNND	International Commission on Nuclear Nonproliferation and Disarmament
ICRP	International Commission on Radiological Protection
ICSANT	International Convention for the Suppression of Acts of Nuclear Terrorism
IDB	Inter-American Development Bank
IEA	International Energy Agency (OECD)
IEC	Incident and Emergency Centre
ILO	International Labor Organization
IMO	International Maritime Organization
INES	International Nuclear and Radiological Event Scale
INF	irradiated nuclear fuel
INFA	International Nuclear Fuel Agency
INIR	Integrated Nuclear Infrastructure Review (IAEA)
INLEX	International Expert Group on Nuclear Liability
INMM	Institute of Nuclear Materials Management
INPO	Institute of Nuclear Power Operations (US)
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
INRA	International Nuclear Regulators Association
INSAG	International Nuclear Safety Group (IAEA)
INSServ	International Nuclear Security Advisory Service (IAEA)
INSSP	Integrated Nuclear Security Support Plan (IAEA)
INTERPOL	International Criminal Police Organization

IPCC	Intergovernmental Panel on Climate Change
IPFM	International Panel on Fissile Materials
IPPAS	International Physical Protection Advisory Service (IAEA)
IRRS	Integrated Regulatory Review Service
IRS	Incident Reporting System (IAEA/NEA)
IsDB	Islamic Development Bank
ISIS	Institute for Science and International Security
ISSAS	International SSAC Advisory Service (IAEA)
ISSC	International Seismic Safety Centre
ITDB	Illicit Trafficking Database (IAEA)
ITE	International Team of Experts (IAEA)
ITER	International Thermonuclear Experimental Reactor
JREMPIO	Joint Radiation Emergency Management Plan of the International Organizations
JSW	Japan Steel Works
KEPCO	Korea Electric Power Corporation
KINS	Korea Institute of Nuclear Safety
LEU	low enriched uranium
LIS	laser-isotope separation
LNG	Liquid Natural Gas
LWGR	light water-cooled graphite-moderated reactor
LWR	light water reactor
MCIF	Major Capital Investment Fund (IAEA)
MDEP	Multinational Design Evaluation Program
MESP	Multilateral Enrichment Sanctuary Project
MIT	Massachusetts Institute of Technology
MOI	Ministry of Industry (Vietnam)
MOST	Ministry of Science and Technology (Vietnam)
MOX	Mixed Oxide Fuel
NAS	National Academy of Sciences (US)
NASA	National Aeronautics and Space Administration (US)
NATO	North Atlantic Treaty Organization
NCACG	National Competent Authorities' Coordinating Group
NEA	Nuclear Energy Agency (OECD)
NEF	Nuclear Energy Futures
NEI	Nuclear Energy Institute
NEPIO	Nuclear Energy Programme Implementing Organization
NERC	North American Electric Reliability Corporation
NERS	Network of Regulators of Countries with Small Nuclear Programmes
NESA	Nuclear Energy System Assessment
NEWS	Nuclear Events Web-based System
NGO	non-governmental organization
NGSI	Next Generation Safeguards Initiative
NIA	Nuclear Industry Association (UK)
NIF	National Ignition Facility (US)
NII	Nuclear Installations Inspectorate (UK)
NJFF	Nuclear Power Joint Fact Finding (Keystone Center)
NNWS	non-nuclear weapon state (NPT)
NPT	Nuclear Nonproliferation Treaty
NRC	Nuclear Regulatory Commission (US)
NRU	National Research Universal reactor (Canada)
NSEL	Nuclear Security Equipment Laboratory (IAEA)
NSF	Nuclear Security Fund (IAEA)
NSG	Nuclear Suppliers Group
NSSG	Nuclear Safety and Security Group (IAEA)
NTI	Nuclear Threat Initiative
NTM	National Technical Means
NUSS	Nuclear Safety Standards (IAEA)
NWFZ	nuclear-weapon-free zone
NWMO	Nuclear Waste Management Organization (Canada)
NWPA	US Nuclear Waste Policy Act (1982)
NWS	nuclear weapon state (NPT)
O&M	operation and maintenance
OECD	Organisation for Economic Co-operation and Development
OEF	operating experience feedback
OER	Operating Experience Reports
OSART	Operational Safety Review Teams (IAEA)
PBMR	Pebble Bed Modular Reactor
PHWR	pressurized heavy water reactor
PIU	Performance and Innovation Unit (UK Cabinet Office)
POC	Point of Contact
PRA	Probabilistic Risk Assessment
PRIS	Power Reactor Information System
PROSPER	Peer Review of the effectiveness of the Operational Safety Performance Experience Review
PSI	Proliferation Security Initiative
PSR	Periodic Safety Review
PUREX	Plutonium Uranium Extraction
PWR	pressurized water reactor
RADWASS	Radioactive Waste Safety Standards (IAEA)
RANET	Response Assistance Network
RBMK	Reaktor Bolshoy Moshchnosti Kanalniy (High Power Channel-Type Reactor)
RDD	radiological dispersal device
REPLIE	Response Plan for Incidents and Emergencies (IAEA)
RWC	Radiological Weapons Convention
SAG	Senior Advisory Group (IAEA)
SAGSI	Standing Advisory Group on Safeguards Implementation (IAEA)
SAGSTRAM	Standing Advisory Group on the Safe Transport of Radioactive Materials (IAEA)
SAL	Safeguards Analytical Laboratory (IAEA)
SEDO	Safety Evaluation During Operation of Fuel Cycle Facilities (IAEA)
SENES	Survey of Emerging Nuclear Energy States
SILEX	separation of isotopes by laser excitation
SMR	small- and medium-sized reactor
SOARCA	State-of-the-Art Reactor Consequences Analysis
SOER	Significant Operating Experience Reports
SOLAS	International Convention for the Safety of Life at Sea
SQP	Small Quantities Protocol (IAEA)
SSAC	State System of Accounting and Control
STUK	Säteilyturvakeskus (Radiation and Nuclear Safety Authority, Finland)
SWU	separative work unit
TCP	Technical Cooperation Programme (IAEA)
TRC	Technical Review Committee (IAEA)
TTA	Nuclear Trade and Technology Analysis unit (IAEA)
TVO	Teollisuuden Voima Oyj (Finland)
UAE	United Arab Emirates
UNFCCC	United Nations Framework Convention on Climate Change
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
URENCO	Uranium Enrichment Company
USSPC	ultra-supercritical pulverized coal
VARANSAC	Vietnam Agency for Radiation Protection and Nuclear Safety Control
VERTIC	Verification Research, Training and Information Centre
VVER	Vodo-Vodyanoi Energeticheskiy Reactor (Russia)
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association
WGRNR	Working Group on Regulation of New Reactors (CNRA)
WHO	World Health Organization (UN)
WINS	World Institute of Nuclear Security
WMD	weapons of mass destruction
WMO	World Meteorological Organization
WNA	World Nuclear Association
WNTI	World Nuclear Transport Institute
WNU	World Nuclear University (WNA)

About CIGI

The Centre for International Governance Innovation is an independent, nonpartisan think tank that addresses international governance challenges. Led by a group of experienced practitioners and distinguished academics, CIGI supports research, forms networks, advances policy debate, builds capacity, and generates ideas for multilateral governance improvements. Conducting an active agenda of research, events, and publications, CIGI's interdisciplinary work includes collaboration with policy, business and academic communities around the world.

CIGI conducts in-depth research and engages experts and partners worldwide from its extensive networks to craft policy proposals and recommendations that promote change in international public policy. Current research interests focus on international economic and financial governance both for the long-term and in the wake of the 2008-2009 financial crisis; the role of the G20 and the newly emerging powers in the evolution of global diplomacy; Africa and climate change, and other issues related to food and human security.

CIGI was founded in 2002 by Jim Balsillie, co-CEO of RIM (Research In Motion) and collaborates with and gratefully acknowledges support from a number of strategic partners, in particular the Government of Canada and the Government of Ontario. CIGI gratefully acknowledges the contribution of the Government of Canada to its endowment fund. Support from the Government of Ontario includes a major financial contribution to the Nuclear Energy Futures project.

Le CIGI a été fondé en 2002 par Jim Balsillie, co-chef de la direction de RIM (Research In Motion). Il collabore avec de nombreux partenaires stratégiques et leur exprime toute sa reconnaissance pour leur soutien. Il remercie tout particulièrement le gouvernement du Canada pour sa contribution à son Fonds de dotation, de même que le gouvernement de l'Ontario, dont l'appui comprend une aide financière majeure au projet Perspectives de l'énergie nucléaire.

Publications Team

Senior Director for Publications: Max Brem
Publications Coordinator: Jessica Hanson
Media Designer: Steve Cross
Copy Editors: Matthew Bunch and Tammy McCausland

Media Contact

For media enquiries, please contact:
Mary-Lou Schagena
Communications Specialist
Tel: +1.519.885.2444 x238, mschagena@cigionline.org

The Centre for International Governance Innovation

Centre pour l'innovation dans la gouvernance internationale

57 Erb Street West

Waterloo, Ontario N2L 6C2, Canada

tel +1 519 885 2444 fax +1 519 885 5450

www.cigionline.org