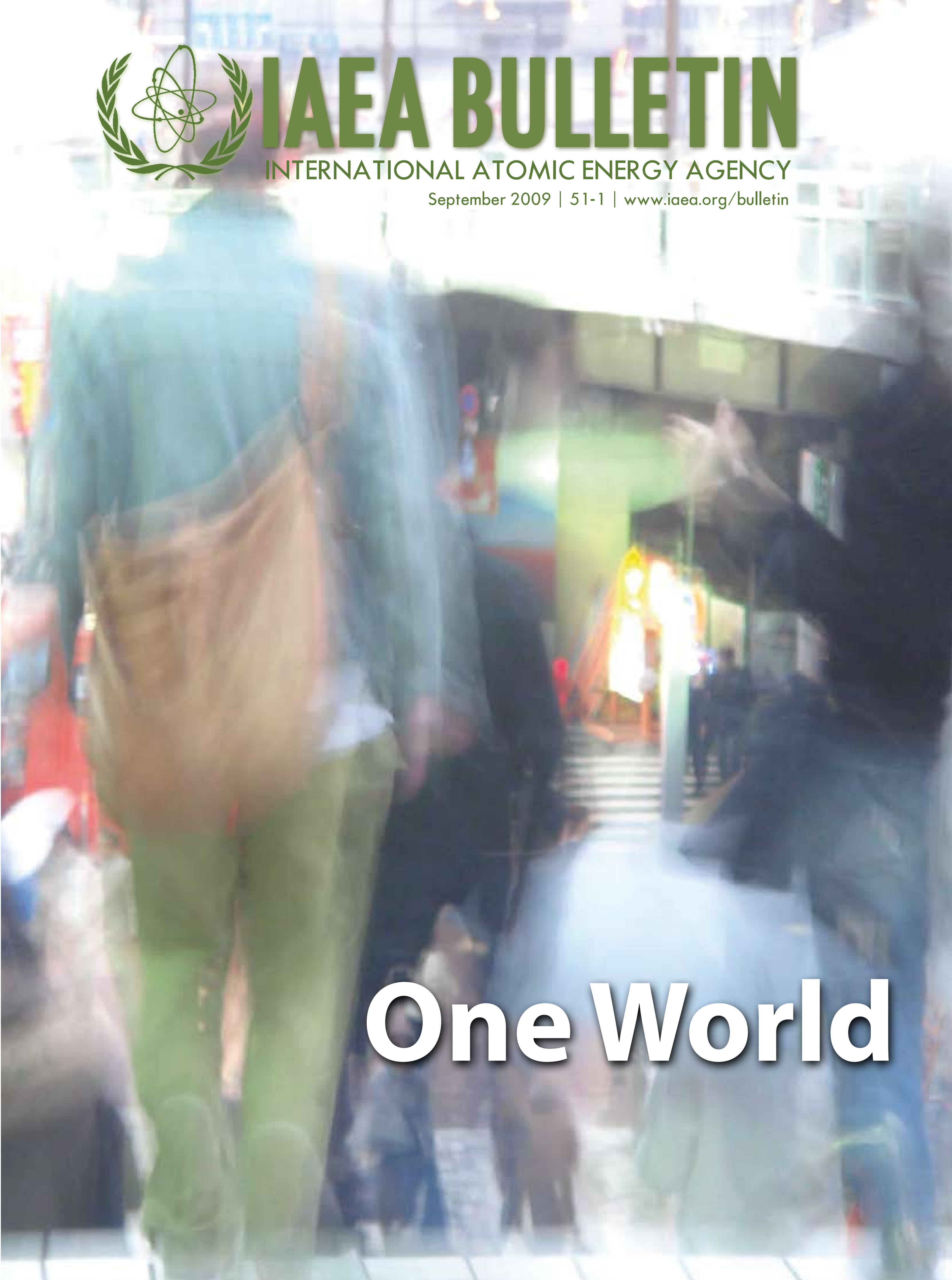


IAEA BULLETIN

INTERNATIONAL ATOMIC ENERGY AGENCY

September 2009 | 51-1 | www.iaea.org/bulletin

One World

To Kill a Pest • The Big Fix • Livestock Production in Honduras

IAEA

The International Atomic Energy Agency is the world's centre of nuclear cooperation. Created in 1957 as the intergovernmental "atoms for peace" organization within the UN system, the IAEA contributes to global peace, development, and security in essential ways — helping to prevent the spread of nuclear weapons, and fostering safe, secure and peaceful uses of beneficial nuclear technologies for human development.

The IAEA mission covers three main pillars of work, with authority rooted in its Statute:

❶ **Safeguards & Verification**, including safeguards inspections under legal agreements with States to verify the exclusively peaceful nature of nuclear material and activities.

❷ **Safety & Security**, including the establishment of safety standards, codes, and guides and assistance to help States apply them.

❸ **Science & Technology**, including technical and research support for nuclear applications in health, agriculture, energy, environment and other fields.

The work is multi-faceted and engages multiple governmental and other partners at national, regional and international levels in and outside the UN system. IAEA programmes and budgets are set through decisions of its own policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States. Reports on IAEA activities are submitted periodically or as cases warrant to the UN Security Council and UN General Assembly.

The Agency is headquartered at the Vienna International Centre in Vienna, Austria. Operational field and liaison offices are centred in Toronto, Canada; Geneva, Switzerland; New York, USA; and Tokyo, Japan. The IAEA runs or supports research centres and scientific laboratories in Vienna and Seibersdorf, Austria; Monaco; and Trieste, Italy.

The IAEA Secretariat is a team of 2300 professional and support staff led by **Director General Mohamed ElBaradei** and six Deputy Directors General who head the major departments:

Mr. David Waller
Management

Mr. Olli Heinonen
Safeguards

Mr. Yuri Sokolov
Nuclear Energy

Mr. Werner Burkart
Nuclear Science & Applications

Ms. Ana Maria Cetto
Technical Cooperation

Mr. Tomihiro Taniguchi
Safety & Security

ONE WORLD

Science, it is often said, should help us make sense of the world, giving us the tools, often even linguistic tools, to understand reality.

The 'butterfly effect' is an example of an expression originating from the scientific community that has become part of the average vocabulary. In its original meaning as part of Chaos Theory it was used to express the concept that small variations in the initial conditions of a system can bring about significant consequences.

Yet, with time and ever increasing popularity among non scientists, its meaning has been extended to include a somewhat simpler concept: that all things are connected.

"No man is an island," famously wrote the XVI century English poet John Donne in one of his Meditations. Men, communities, institutions and states are all connected together in ways that often we can only barely fathom.

In an international agency such as the IAEA, the threads that connect people, communities and states are often laid bare to see. With its 150 Member States and multiple partners, the IAEA fosters cooperation in the nuclear field, promoting safe, secure and peaceful nuclear technologies.

Yet, at a time of economic and financial upheavals, the temptation to entrench ourselves behind personal, social or national barriers can be alluring.

That temptation, however, should be resisted.

In a globalized world, global issues require global solutions that can only be delivered through international cooperation, as many authors of the articles featured in this issue of the IAEA Bulletin say.

In the health sector, diseases originating from animals are increasingly threatening the livelihood and health of millions of people worldwide. Dr. Nabarro explains that international cooperation is crucial in the fight against these pathogens.

Similarly, Yuri Sokolov and Randy Beatty tell the story of how the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was developed as a partnership for dialogue and innovation of nuclear power.

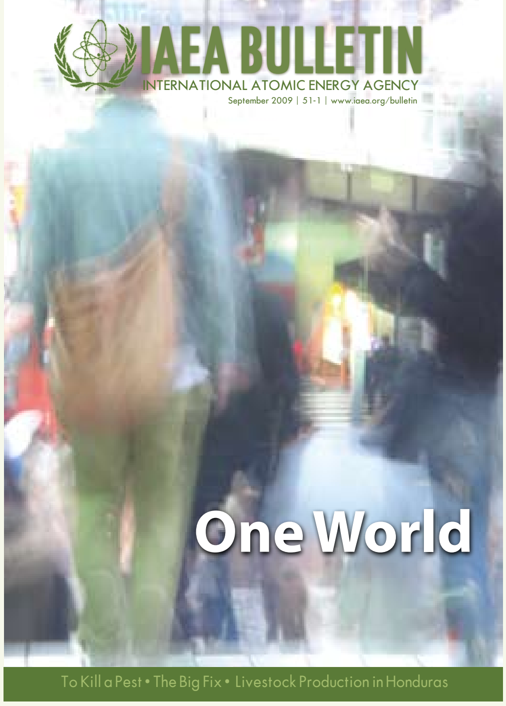
Tariq Rauf and Zoryana Vovchok explain that several mechanisms are under consideration to guarantee assurances of supply of nuclear fuel to States, while Vilmos Cserveny describes the IAEA's role in the nuclear non proliferation regime as the world prepares to review the Non-Proliferation of Nuclear Weapons Treaty (NPT).

African countries recently gave a notable example of cooperation by officially renouncing nuclear weapons. With the entry into force of the Treaty of Pelindaba, all territories in the Southern Hemisphere are now free of nuclear weapons.

A review conference of the NPT is due next year. The hope is that wisdom will prevail and that all will cooperate to make the world a safer place.

We are all together in this. We are one world.

— Giovanni Verlini, Editor



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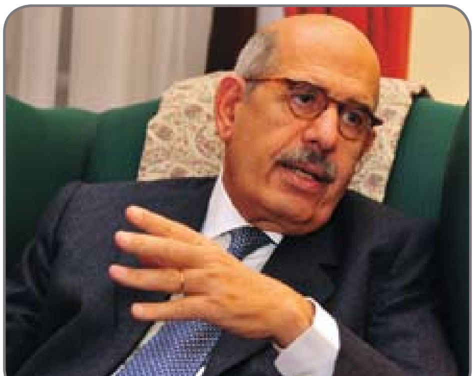
"The UN's High-Level Panel famously described the work of the Agency as an "extraordinary bargain." For me, working here for the past quarter century has been an extraordinary and enriching experience which I will treasure."

— Dr. Mohamed ElBaradei, IAEA Director General, p14

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SNAPSHOTS

Global Plan Against "Stem Rust"

Scientists are accelerating research into new varieties of wheat to identify those resistant to an aggressive fungus that is destroying harvests in African and Middle Eastern countries. About 90% of commercial high-yielding wheat is vulnerable to Ug99, known as "stem rust".

Wheat provides 20% of the world's calories, and Ug99 is capable of cutting wheat yields by 20 to 80 percent, with isolated incidents of 100 percent destruction.

(Photo: Photodisc)

Southern Hemisphere Territories Free of Nuclear Weapons

A Treaty making Africa into a zone free of nuclear weapons entered into force on 15 July 2009, in turn expanding the nuclear-weapon free territories to cover the entire Southern hemisphere.

The Treaty of Pelindaba entered into force when Burundi deposited its instrument of ratification, becoming the 28th nation to do so.

Similar Treaties are in force in South America (Treaty of Tlatelolco), the South Pacific (Treaty of Rarotonga), Southeast Asia (Treaty of Bangkok), and Antarctica (Antarctic Treaty).

WHO-IAEA Join Forces to Fight Cancer

The World Health Organization (WHO) and the IAEA have launched of a Joint Programme on Cancer Control, aimed at strengthening and accelerating efforts to fight cancer in the developing world.

The groundbreaking agreement reflects growing international concern over the global cancer burden and its projected increase. Latest statistics indicate that cancer will be among the leading causes of deaths, with more than 70% of all cancer deaths occurring in low- and middle-income countries.

from our image bank

Ionizing radiation is being used to protect people from food borne illnesses caused by harmful micro-organisms. Currently, food irradiation is approved for use in over 55 countries worldwide.

For more information and photos visit www.iaea.org

60

A total of 60 countries are now considering nuclear power as part of their future energy mix, while 20 of them might have a nuclear power programme in place by 2030, according to the IAEA's nuclear energy department.

Nuclear Knowledge at the Click of a Button

The IAEA is making its International Nuclear Information System (INIS) available for free to Internet users around the world.

The INIS online database contains over 3 million bibliographic records and almost 200, 000 full text documents classified as nonconventional literature, consisting of reports and other non copyrighted information.

Established in 1970, INIS processes most of the world's scientific and technical literature on a wide range of subjects from nuclear engineering, safeguards and non-proliferation to applications in agriculture and health.

Visit http://inisdb2.iaea.org

Japan's Yukiya Amano to be next IAEA Director General

The 35-member IAEA Board of Governors selected Ambassador Yukiya Amano of Japan as next IAEA Director General. His term as Director General would begin 1 December 2009.

Ambassador Amano is to become the fifth Director General of the IAEA in its 52-year history.

(see article "Change at the Top" in this issue of the IAEA Bulletin)

(Photo: D. Calma/IAEA)

"Genbaku No Hi" (Atomic Bomb Memorial Day)

A call to bring about an end to all nuclear weapons was renewed during a ceremony held on 7 August at the Vienna International Centre (VIC) to remember the destruction of the cities of Hiroshima and Nagasaki in August 1945. (Photo: D.Calma/IAEA)

Safe Recycled Metal Trade

The presence of inadvertent radioactive materials in metal scrap is a recurring worldwide problem for the metal recycling industry. The materials can pose potentially severe health, environmental, and financial consequences for the industry and the public alike.

"In the last three years the IAEA has become aware of around 500 events involving uncontrolled ionizing radiation sources, about 150 of which were related to sources found in scrap metal or contaminated goods or materials," says Eliana Amaral, Director of the IAEA's Division of Radiation, Transport and Waste Safety.

"This is clearly a global problem that requires the application of a harmonized approach throughout the different regions of the world involving all stakeholders."

Road to Disarmament

IAEA safeguards: a fundamental pillar of the NPT regime

This is an excerpt from Vilmos Cserveny's statement at the General Debate of the NPT Preparatory Committee held in New York, USA on 4 May 2009.

There is great expectation in the international community that, with revived leaderships, States parties to the Non Proliferation of Nuclear Weapons Treaty (NPT) come together with a renewed unity of purpose to prepare the groundwork for a successful outcome to the 2010 NPT Review Conference. The shared objectives to this end include a common vision to make the peaceful applications of nuclear energy available to all States parties, to prevent the acquisition of nuclear weapons by other States, and to achieve a world free of nuclear weapons, as envisaged in the Treaty.

The NPT consists of three equally important pillars — nuclear non-proliferation; peaceful nuclear cooperation; and nuclear disarmament — and the premise that progress in any one pillar strengthens the integrity of the whole.

The activities of the IAEA are also based on three pillars. Through its work on nuclear verification, nuclear safety and security, and nuclear technology, the IAEA continues to play a key role as a catalyst for sustainable development and as a cornerstone for nuclear safety, security and verification of compliance with nuclear non-proliferation commitments.

Verification of Compliance

In the 2000 Final Document, States Parties reiterated that IAEA safeguards are a fundamental pillar of the nuclear non-proliferation regime, play an indispensable role in the implementation of the Treaty and help to create an environment conducive to nuclear disarmament and to nuclear cooperation. It also reaffirmed that the IAEA is the sole competent authority responsible for verifying and assuring, in accordance with its Statute and the IAEA's safeguards system, compliance with States' obligations under Article III 1 of the Treaty.

The IAEA's verification experience, particularly after 2000, has underlined that non-proliferation obligations of direct relevance to national and international security not only must be strictly complied with, but also be seen to be complied with, if the required assurance is to be obtained. And, ideally, assurance of compliance, and early warning in case of non-compliance, should be extended to cover all the obligations embodied in or emanating from the NPT.

As we approach the 2010 NPT review, discussions will inevitably focus, inter alia, on questions of verification and States' compliance of their undertakings. The IAEA's verification work has shown that when international inspectors are provided adequate authority, are aided by all available credible information, backed by an effective compliance mechanism, and supported by international consensus, the current verification system is able to provide reliable, technically sound, impartial information that would not otherwise be possible. However, our experience has also demonstrated in recent years that, in the absence of one or more of these elements, the IAEA may not be able to provide the required assurance.

The IAEA's Safeguards System

The effectiveness and efficiency of the IAEA's safeguards system to provide credible assurance about the peaceful use of nuclear material and activities in a non-nuclear-weapon States (NNWS) party depends on several factors — the most important of which is whether the State has brought into force a comprehensive safeguards agreement (CSA) and an additional protocol (AP). I should underline in this connection the continuing validity of the Director General's call in 2005, and in many fora since, for the recognition by the NPT States Parties that the additional protocol is an integral part of IAEA safeguards in every country party to the NPT and is within its overall safeguards mandate under Article III 1 of the Treaty. It is regrettable that there continues to be a lack of consensus among the States Parties in this regard.

To clarify, the NPT provides that States will accept safeguards on all nuclear material in all peaceful nuclear activities. Accordingly, NPT CSAs provide for the IAEA's right and obligation to ensure that safeguards are applied as noted above. Thus, by concluding a CSA, NPT NNWS accept the legal obligation to declare all nuclear material in all peaceful nuclear activities and recognize the Agency's right and obligation to ensure that safeguards are applied to all nuclear material that has been declared and should have been declared. In this regard, the AP gives the IAEA the required tools to verify the absence of undeclared nuclear material and activities. Thus, as the Director General has stated repeatedly, without a CSA and an AP in force, the IAEA cannot provide the required assurances of the non-diversion of declared nuclear material from peaceful nuclear activities and the absence of undeclared nuclear material or activities.

Since the 2005 NPT Review Conference, 25 NPT States have signed APs and 24 have brought APs into force. This brings the number of NPT States that have signed APs to 120 and those with APs in force to 91. Progress has therefore been steady; nearly three quarters of States with CSAs have signed APs and more than half of States with CSAs now have APs in force. Moreover, nearly three quarters of the countries with nuclear material under safeguards have additional protocols in force.

In connection with safeguards agreements, I would also point to the importance of a new safeguards strengthening measure adopted by the IAEA since the 2005 NPT Review Conference. The IAEA has closed a historical lacuna in its safeguards system by modifying the standard text of the so-called small quantities protocol (SQP) to comprehensive safeguards agreements under which many important safeguards measures were held in abeyance for those NNWS with little or no nuclear material and no nuclear material in a facility. In September 2005, the IAEA Board of Governors decided that, in future, SQPs would no longer be available to States with an existing or planned facility; States that continue to qualify for an SQP would be required to provide initial reports on nuclear material and notify the IAEA as soon as a decision has been taken to construct or authorize the construction of a nuclear facility; and allow for IAEA inspections. So far, 31 States with SQPs have accepted the revised standardized SQP text.

Strengthening the System

The preparations for the 2010 review of the NPT provide a good opportunity to examine and discuss ways in which IAEA verification under the NPT can be further strengthened. Some of the technical measures by which the Secretariat seeks to strengthen the IAEA's safeguards system are mentioned here.

In the area of provision of additional information on nuclear technologies, the review of Annexes I and II of the Model Additional Protocol could assist the IAEA in obtaining a fuller picture of States' nuclear activities. Similarly, the provision of relevant information on exports of specified equipment and non-nuclear material, procurement enquiries, export denials, and relevant information from commercial suppliers would improve the IAEA's ability to detect possible undeclared activities by enhancing the IAEA's State evaluation process and could also improve the IAEA's ability to respond to the challenges of clandestine nuclear trade.

With regard to the expansion of the IAEA 's technical capabilities, it is to be noted that the technical capabilities of the IAEA's Safeguards Analytical Laboratory in Seibersdorf and the sample analysis capacity of the IAEA's Network of Analytical Laboratories clearly are insufficient to process the increasing number of environmental samples collected for safeguards verification purposes in a timely and fully independent manner. As a consequence, the Secretariat urgently requires new resources to maintain and expand the number of its qualified network laboratories and to enhance the IAEA's own analytical laboratory in Austria.

Also regarding the expansion of the IAEA's technical capabilities, the IAEA requires better access to commercial satellite imagery, as well as new types of satellite imagery, such as high-resolution optical imagery, and the associated human resources for effective analysis of satellite images.

Providing adequate financing for the safeguards system remains a critical challenge. The IAEA safeguards over 900 facilities in some 70 countries, with a safeguards budget of about €130 million. Clearly, this is insufficient for the IAEA to meet the challenges that the safeguards system is facing. In particular the IAEA needs resources for special verification equipment and instrumentation. Investments of €11.4 million are required to effectively respond to the increasing complexity of the IAEA's verification mission. In addition, new facilities expected to come under safeguards also will require significant additional resources. In view of these steadily increasing and high costs of safeguards applications, new and innovative financial solutions appear to be needed.

Safeguards Implementation

As reported in the safeguards implementation report (SIR) for 2008, for 51 of the 84 States with both CSAs and APs in force, the Agency concluded that all nuclear material remained in peaceful activities; for the remaining 33 States, the Agency had not yet completed the necessary evaluations and could

Road to

therefore only conclude that the declared nuclear material remained in peaceful activities.

The same conclusion on the non-diversion of declared nuclear material was drawn for the 70 States with CSAs in force but no APs. Safeguards conclusions were also drawn for five nuclear-weapon-States with voluntary offer safeguards agreements and for three non-NPT States that have item-specific safeguards agreements with the Agency.

New Framework for the Nuclear Fuel Cycle

It is generally recognized that States relying, or considering relying, on nuclear power need to have confidence in the ability to obtain nuclear fuel in a predictable, stable and cost effective manner over the long term. Furthermore, while continuing to rely on a well functioning international nuclear fuel market, States may also need to have back-up options with the objective of protecting against political disruptions of the supply of required nuclear fuel for their nuclear facilities. Such supply disruptions could create vulnerabilities in the security of supply of nuclear fuel through market arrangements and they might also dissuade States from initiating or expanding their nuclear power programmes.

Currently, there are around 12 proposals made regarding various aspects of assurances of nuclear fuel supply. They range from continuing reliance on the existing commercial market, supply assurances by the nuclear industry and the respective Governments, low enriched uranium (LEU) reserves for supply of last resort, to international nuclear fuel centres. These proposals are at different stages of development. If implemented, they would enable States to resort to them according to their interest and needs thereby increasing their overall level of assurance of supply of uranium services, LEU, nuclear fuel or fuel fabrication services.

Facilitating Access to Nuclear Technologies

The technical cooperation programme has, for nearly five decades, been the principal mechanism through which the IAEA supports the use of appropriate nuclear science and technology to address development priorities of its Member States. The role the IAEA plays in the vast area of development is strategic but modest, making specific targeted contributions in activities where nuclear techniques have a comparative advantage.

The programme is a shared responsibility, developed in close collaboration with the Member States, from initial formulation to implementation and evaluation. The programme goals and objectives are aligned with the development goals and objectives of the Member States. In this way, the Agency supports the achievement of the United Nations Millennium Development Goals.

In 2008, a total of $96.4 million was disbursed to 122 countries and territories under the programme. 3240 expert and lecturer assignments were carried out, 3676 participants attended meetings, 2744 people took part in 177 training courses and 1621 benefited from fellowships and scientific visits.

The largest segment of the technical cooperation programme in 2008 was human health, accounting for 26.8%. The second largest segment was food and agriculture, accounting for 14.0%. Isotope and nuclear techniques have demonstrated their utility in understanding water dynamics, past climates and in assessing available resources. Energy is central to sustainable development and poverty reduction efforts. Through an integrated system approach, the IAEA's technical cooperation programme helps Member States develop the skills and understanding needed to assess national energy requirements, prepare energy plans and alternative scenarios, enable policy frameworks, develop national capacities and capabilities and provide knowledge-based advisory services for expanding access to energy services for the poor.

While every country has the right to use nuclear power as an energy source, it also has the responsibility to ensure that this energy source is employed in a safe and secure manner. Therefore, safety and security issues cut across all technical cooperation activities of the IAEA and are tailored to fit a country's specific situation.

In short, the IAEA technical cooperation programme works towards enhancing acceptability, accessibility and affordability of nuclear technologies for development while assisting its Member States through the transfer of technology, decision making support, planning tools, capacity and knowledge building and R&D coordination.

Nuclear Safety and Security

The IAEA's role in facilitating access to nuclear technologies for its Member States is also linked to its statutory obligation to provide for the application of its standards of safety to its operations. As the uses and the introduction of nuclear technologies expand, so must the vigilance of the global nuclear community. Levels of safety and security — which are primarily under national responsibility — must keep pace with emerging technologies, expanding nuclear programmes and new entrants to the nuclear community. While in recent years the safety performance of the nuclear industry has been good, it is important to avoid any complacency. Therefore, the IAEA continues to support and promote the global nuclear safety and security regime as a framework for worldwide achievement of high levels of safety and security in nuclear activities.

Among the global trends, issues and challenges in nuclear safety in 2008, one could observe the continuous improvements focusing on knowledge networking, operating experience feedback, self-assessment and peer review. At the same time, activities related to the expansion of nuclear programmes centred on national safety infrastructures, human resources and capacity building, regulatory independence, nuclear incident and emergency preparedness and response, spent fuel and radioactive waste management as well as multinational aspects of nuclear activities. Furthermore, there was increasing awareness that safety activities should not compromise security and vice versa.

The IAEA's nuclear security programme is designed to assist national efforts to meet the requirements of those instruments and to address the risk from non-State actors and the malicious use of radiological material.

In 2008, the Agency continued to provide assistance through the nuclear security programme to national efforts. For example, physical protection upgrades were underway in nuclear facilities in 12 States, more than 1,500 radioactive sources were moved to secure storage and over 1,600 people from 90 States received training in various aspects of nuclear security related work. Currently 106 States participate in the IAEA Illicit Trafficking Database (ITDB) and, as of April 2008, States had reported or otherwise confirmed to the ITDB 1644 incidents of illicit trafficking and other unauthorized activities involving nuclear and radioactive materials.

Over 95% of the funding for these activities came from voluntary contributions. However, over the past few years, it has become apparent that this funding mechanism is unsustainable. If the Agency is to fulfil the demands placed upon it by its Member Sates and the international community at large, it must have predictable and assured funding for nuclear security work.

The NPT

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is a landmark international treaty whose objective is to prevent the spread of nuclear weapons and weapons technology, to promote cooperation in the peaceful uses of nuclear energy and to further the goal of achieving nuclear disarmament and general and complete disarmament. The Treaty represents the only binding commitment in a multilateral treaty to the goal of disarmament by the nuclear-weapon States. Opened for signature in 1968, the Treaty entered into force in 1970. On 11 May 1995, the Treaty was extended indefinitely. A total of 190 parties have joined the Treaty, including the five nuclear-weapon States. More countries have ratified the NPT than any other arms limitation and disarmament agreement, a testament to the Treaty's significance.

The provisions of the Treaty, particularly article VIII, paragraph 3, envisage a review of the operation of the Treaty every five years, a provision which was reaffirmed by the States parties at the 1995 NPT Review and Extension Conference.

To further the goal of non-proliferation and as a confidence-building measure between States parties, the Treaty establishes a safeguards system under the responsibility of the IAEA. Safeguards are used to verify compliance with the Treaty through inspections conducted by the IAEA. The Treaty promotes cooperation in the field of peaceful nuclear technology and equal access to this technology for all States parties, while safeguards prevent the diversion of fissile material for weapons use.

The 2005 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons met at the United Nations in New York from 2 to 27 May 2005. A total of 153 States parties to the Treaty participated in the event. The Conference was unable to produce a consensus substantive outcome on the review of the implementation of the provisions of the Treaty.

The 2010 NPT Review Conference is scheduled to be held in New York, USA, from 26 April to 21 May 2010.

Future of the IAEA

Wherever we turn in today's world, it is evident that the intertwined issues of security and development continue to be the most daunting challenges facing humanity. It is becoming more evident that the IAEA has an increased and more important role to play in both fields.

Vilmos Cserveny is IAEA Assistant Director General for External Relations and Policy Coordination. E-mail: v.cserveny@iaea.org.

nament

A Secure Nuclear Future

by Tariq Rauf and Zoryana Vovchok

Several mechanisms are under consideration to guarantee assurances of supply of nuclear fuel to States.

Early in the nuclear age, in 1946, the US diplomat Bernard Baruch called for States to transfer ownership and control over civil nuclear activities and materials to an international atomic development agency. Ultimately, however, it was the 1953 Atoms-for-Peace plan that provided the principles underlying international cooperation in the field of nuclear technology and the establishment of both the International Atomic Energy Agency (IAEA) and later the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). In so doing, it became not only the forbearer of international nuclear cooperation and non-proliferation efforts in an overarching sense, but also of recent efforts of possible multilateral approaches to the nuclear fuel cycle.

The line between the peaceful and the military atom is, in some cases, merely a reflection of the intentions of those making use of the technology. It remains essential that nuclear energy is used responsibly under the highest standards for non-proliferation, security and safety.

The first feasibility study on multilateral approaches to the nuclear fuel cycle was on *Regional Nuclear Fuel Cycle Centres (RFCC)* in 1975–1977, to examine the possibility of joining together to set up fuel cycle centres at selected sites. In keeping with the concerns in the 1970s, the emphasis in this and other studies of the time was on the back end of the cycle. *The International Nuclear Fuel Cycle Evaluation (INFCE)* study of 1977–1980 discussed the possibility of regional fuel-cycle facilities and prospects for multilateral cooperation on plutonium storage. Both studies came to similarly positive technical conclusions, however, due in large part to diminishing concerns over the likelihood of a "plutonium economy," the disinclination of some countries to give up national control over reprocessing, and the general lack of political will, neither the RFCC or INFCE studies resulted in any further pursuit of multilateral approaches.

The IAEA *Expert Group on International Plutonium Storage (IPS)* in 1978-1982, the next initiative in the field, moved away from the discussion of regional fuel-cycle centres to examine instead the prospects for IAEA-supervised management, storage, and disposition of spent nuclear fuel. Once again, no consensus was reached, as States were unwilling to renounce sovereign control over nuclear technology and fuel. The same fate met the studies undertaken by the IAEA *Committee on Assurances of Supply (CAS)* in 1980. The efforts that began in the 1970s in the area of multilateral approaches finally ended with the *UN Conference for the Promotion of International Cooperation in the Peaceful Uses of Nuclear Energy (UNCPICPUNE)* in 1987, but like its predecessors, it yielded little in the way of concrete results in this regard.

All of these initiatives failed for a variety of political, technical and economic reasons, but principally because States could not agree on the non-proliferation commitments and conditions that would entitle them to participate in the multilateral activities — much as unfortunately seems to be the case now.

Recent moves

Over recent years, two approaches have been put forward: both seek to ensure that the global nuclear non-proliferation regime maintains its authority and credibility in the face of new challenges. One is based on the further denial of nuclear technology to non-nuclear-weapon States and the reinterpretation of the NPT provisions governing the transfer of nuclear technologies. Not surprisingly, this approach did not succeed given the increasing unwillingness of many non–nuclear-weapon States to accept additional restrictions to their right to peaceful nuclear technology under the NPT. The other approach relies on assurances of supply and multinational alternatives to national operations of uranium-enrichment and plutonium-separation technologies, and to storage of spent nuclear fuel.

The first to suggest a fresh look at multilateral approaches was IAEA Director-General Mohamed ElBaradei at the September 2003 IAEA General Conference. He proposed that multilateral approaches, based on improved nuclear technology control, greater operational transparency, and nuclear fuel and power plant supply assurances, could serve to strengthen the nuclear non-proliferation regime while not impeding the development of nuclear energy for States wishing to choose that option.

Since September 2003, some 12 mutually complementary proposals have emerged ranging from assurances of supply of low enriched uranium (LEU) to LEU reserves to new multilateral uranium enrichment centres.

By June 2009, three front runner concepts had emerged on assurances of supply of LEU: the establishment of an IAEA LEU Bank; Russian Federation Initiative to establish a reserve of LEU for supply to IAEA for its Member States; and the Multilateral Enrichment Sanctuary Project (MESP) of Germany. In addition, the United Kingdom is developing its enrichment bonds proposal in the form of Nuclear Fuel Assurances. These proposals aim to add to States' nuclear fuel options by backing up the commercial market with an assurance scheme, which would increase confidence in continuing reliance on nuclear energy.

Enriched Uranium Reserves

Two current proposals call for the establishment of LEU reserves under IAEA auspices. An IAEA LEU Bank is envisaged with 60 tonnes of LEU that would be sufficient to meet the electricity needs of 2 million average Austrian households for 3 years. In addition, a Russian LEU reserve is envisaged with 120 tonnes of LEU, which would provide 6 years of electricity supply for the same number of households.

Why only LEU and not also fuel fabrication?

The creation of dedicated LEU stocks under IAEA auspices for assurance of supply would be a historic first in the era of nuclear energy. To provide nuclear fuel ready for use in power plants would also require the availability of fuel fabrication services that would fabricate LEU into fuel assemblies. According to the latest IAEA data, there are now 13 enrichment facilities in 9 countries versus 34 fabrication plants in 18 States. This shows that fuel fabrication services are more widely dispersed than enrichment services; thus justifying an initial focus on supply assurance of LEU. It needs to be understood that assurance of LEU supply is a first step and fuel fabrication would be considered at a later stage.

Why LEU and not also natural uranium?

Another relevant question pertains to assurance of supply of natural uranium (NU) which is the fuel source for certain types of power reactors. The data show that the vast majority of nuclear power plants (NPPs) comprise of light-water reactors (LWRs) using LEU, while the number of CANDU (heavy-water) reactors using natural uranium is relatively small and such fuel is easier to fabricate as it does not require uranium enrichment services.

Currently, only 48 NPPs use natural uranium — 44 PHWRs and 4 MAGNOX reactors, this amounts only to 11% of all NPPs available world wide. In contrast, 388 NPPs or 89% of NPPs in the world use LEU. Thus, it is clear that at the outset of setting up a new framework for nuclear energy, an initial focus on LEU supply assurance is both warranted and necessary.

Assurance of supply mechanisms have two co-equal objectives. They are designed to facilitate the continuing and future use of nuclear energy in IAEA Member States as well as to strengthen the nuclear non-proliferation regime by offering alternatives to the establishment of new enrichment facilities.

Similar assurance for NU supply, though important, could follow at a later stage.

An IAEA LEU Bank is envisaged with 60 tonnes of LEU that would be sufficient to meet the electricity needs of 2 million average Austrian households for 3 years.

Uranium supply to the IAEA

Uranium exporters and suppliers have formed themselves into a grouping of nuclear suppliers and regulate their exports and/or transfers of nuclear items through guidelines and national export controls. These criteria are designed to ensure peaceful, non-explosive, uses of nuclear items in conformity with international and national legal instruments. For purposes of assurance of supply of LEU through or by the IAEA, it will be essential that such suppliers provide LEU, NU and enrichment services to the IAEA in the framework of the IAEA Statute and free of any other national and/or international constraints. The necessary non-proliferation, peaceful and non-explosive use obligations governing the supply of LEU by the IAEA through an assurance mechanism would be regulated by the eligibility and supply criteria consistent with the IAEA Statute and approved in advance by the IAEA Board of Governors.

Funding

An IAEA LEU Bank would be funded by extra-budgetary pledges and contributions currently amounting more than $150 million, of which, $51 million have already been deposited in a suspense account with the IAEA. This would be sufficient to purchase some 60–80 tonnes of industry standard LEU (under 5% enrichment level) as well as the required number of storage cylinders. One or more Member States could offer to host the LEU bank at an existing civilian nuclear facility, in which case no additional "running costs" would be incurred. Safeguards costs are estimated for one annual and three interim inspections. Any LEU supplied would be at the prevailing market price, and the proceeds would be used for replenishment. Thus, the LEU bank would be fully funded for the foreseeable future. Additional voluntary contributions in funds or in-kind would be encouraged as a back up.

The Russian LEU Reserve of 120 tonnes of LEU valued at roughly $300 million is fully funded by the Russian Federation, including the cost of the LEU, storage, safety, security, safeguards and other related costs, and the IAEA would not incur any costs. Any LEU supplied to a State would be at the prevailing spot market price, and the proceeds could be used for the replenishment of the reserve.

Who would benefit?

All eligible IAEA Member States would benefit from LEU supply. Both the IAEA LEU Bank and the Russian LEU Reserve would be used as a last resort by a State experiencing a nuclear fuel supply disruption for non-commercial or technical reasons. In the event that any Member State finds itself in circumstances where it needs to call on the reserve, it can request the triggering of the mechanism, and if the State's request fulfils the established criteria, it would receive the LEU from the IAEA.

What are the eligibility criteria?

For the IAEA LEU Bank, any Member State could request supply when its LEU supplies are disrupted for reasons not related to technical or commercial considerations, it has brought into force a safeguards agreement that applies to any LEU supplied from the IAEA bank, has a conclusion on peaceful use / non-diversion of nuclear material in the latest IAEA Safeguards Implementation Report, and no specific safeguards implementation issues are under discussion in the IAEA Board of Governors. The criteria in the case of the Russian LEU Reserve are the same except for the requirement that a requesting State must be a non-nuclear-weapon State and a Member of the Agency, which has placed all of its peaceful nuclear activities under IAEA safeguards.

What are the non-proliferation objectives?

Assurance of supply mechanisms have two co-equal objectives. They are designed to facilitate the continuing and future use of nuclear energy in IAEA Member States as well as to strengthen the nuclear non-proliferation regime by offering alternatives to the establishment of new enrichment facilities. However, neither of the two proposals in any way seeks to limit the nuclear fuel cycle choices of Member States. The rights of Member States, including establishing or expanding their own production capacity in the civilian nuclear fuel cycle under IAEA safeguards, would remain intact and would not in any way be compromised or diminished by the establishment of assurance of supply mechanisms.

In other words, having the right to receive LEU from the bank or the reserve would not require giving up the right to establish or further develop a civilian national fuel cycle or have any adverse impact on it. The additional options for assurance of supply would be over and above the rights that exist at present.

Safeguards

Regarding Member States' safeguards obligations concerning the supplied LEU, it would be required that all Member States would fully honour all of their safeguards obligations that they have freely undertaken with the IAEA, at all times without reservations. Should a Member State regrettably choose to act contrary to its safeguards obligations with respect to the supplied LEU, the IAEA Board would have to be informed as provided for under relevant safeguards agreements and the IAEA Statute as in all cases of failure to respect safeguards obligations. The supplied LEU would remain under safeguards as long as it is relevant from a safeguards perspective as defined by the Agency.

Location of an IAEA LEU bank?

One or more Member States could offer to provide a location for the IAEA LEU bank at existing nuclear facilities. For this purpose, the IAEA would conclude a Host State Agreement providing for, inter alia, privileges and immunities, including provisions for impediment free independent operation of the bank by the IAEA, all authorizations for the IAEA to transport of the LEU to/from the storage location, including transit through any neighbouring States, if required.

On 18 May 2009, the IAEA received from Kazakhstan a position paper noting that it would consider providing a location in Kazakhstan for the IAEA LEU Bank, once the Board has authorized its establishment.

Fears and suspicions

Evidently, despite numerous discussions on fuel assurances and multilateral approaches to the nuclear fuel cycle, suspicions linger on among potential customer or so-called recipient States. First, they remain sceptical as all current proposals for multilateral approaches to the nuclear fuel cycle emerge from nuclear supplier States. Second, they tend to view fuel assurances and multilateral approaches to the nuclear fuel cycle as a projection of future restrictions of the use of sensitive technologies by additional States, even under appropriate IAEA safeguards in accordance with the NPT. This has provoked a backlash from many States which regard such moves as limiting their inalienable right to peaceful uses of nuclear energy as enshrined in the NPT.

The proponents of fuel assurances have assured repeatedly that none of the proposals seeks to limit or restrict any rights to the nuclear fuel cycle for peaceful uses. Nonetheless, doubts and suspicions persist regarding supplier State restrictions on peaceful uses of nuclear energy, and are exacerbated by perceptions of broken promises for nuclear disarmament by States possessing nuclear weapons. It is hoped that the recent "reset" of US-Russian negotiations on verified nuclear arms reductions would lead to an improved context for progressing fuel assurances.

None of the front-runner proposals noted above restrict the rights of States to peaceful uses of nuclear energy. They offer possibilities for assurances of supply that would not only increase options for securing LEU but also increase confidence in reliable access to nuclear fuel over the longer term.

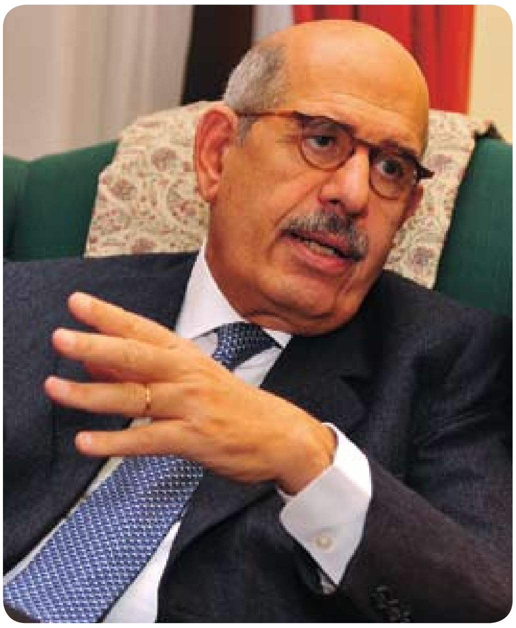
Next Steps

Establishing LEU reserves under IAEA auspices would be the first step in setting up a new framework for the utilization of nuclear energy. Such reserves could in time be bolstered by assurances of fuel fabrication. Any fuel banks under IAEA aegis would be equally accessible by all Member States in accordance with criteria established in advance by the Board of Governors. It is unrealistic to expect that any LEU supplies by or through the IAEA would be unconditional — they would be in full conformity with the provisions of the IAEA Statute.

It is increasingly clear that the future of nuclear energy lies in enhanced non-proliferation, security and safety. Nuclear fuel banks, multilateral enrichment centres, and assurances of supply will remain key to the continued reliance and future expansion of nuclear energy. In this regard, results-oriented open and transparent discussions are vital and the IAEA remains the logical forum for Atoms for Peace in the 21st century.

Tariq Rauf is Head of Verification and Security Policy Coordination at the IAEA. Zoryana Vovchok is an External Relations and Policy Coordination Officer at the IAEA's Office of External Relations and Policy Coordination.

An Extraordinary Experience


D.Calma/IAEA

Giovanni Verlini spoke with outgoing IAEA Director General Mohamed ElBaradei about his time at the IAEA and what lies ahead for the Agency.

Question: When you were first elected to head the IAEA in 1997, you focused attention on three pillars of work — nuclear safety, safeguards, and technology — and the importance of balance among them. In what ways is this nuclear balance important today?

Mohamed ElBaradei: The Agency's mandate is unique in that it addresses both security and development. Our job is to prevent the spread of nuclear weapons with a view to achieving a world free of them, and to make the benefits of nuclear technology available for peaceful purposes to developing countries. You cannot have development without security and vice versa.

One of our failings as an international community — and often as human beings — is that we too easily address symptoms rather than causes, or deal with issues in isolation rather than holistically. In the case of nuclear proliferation, the international community would be more effective if it simultaneously asked "What are the many reasons why some countries seek to obtain weapons of mass destruction?" and tried to address those, instead of simply insisting "No-one else can have these weapons." That means addressing issues such as poverty and the lack of good governance and democracy. The huge divide between the "haves" and "have nots" of this world creates a deep sense of injustice which makes it easier for extremists of all stripes to preach violence and encourages efforts to obtain nuclear or other weapons of mass destruction. We also need to address festering conflicts that have been going on for decades and which, again, can lead parties to such conflicts to seek to acquire weapons of mass destruction in order to achieve parity with rivals or domination over them. The Middle East, South Asia and East Asia are cases in point.

The remedy for this is a sustained development effort to enable every human being to live in freedom and dignity, plus meaningful dialogue to address these persistent conflicts on the basis of fairness and equity.

As far as the work of the Agency is concerned, the importance of all areas of our work — technology, safeguards, safety and security and technical cooperation — has grown exponentially during the last 12 years. Member States expect more and more of us in all of these areas.

Countries have different priorities in terms of what they expect — whether the emphasis is on verification or on technology for development — and it is important that they see their priorities adequately reflected in the work of the Agency. Getting the balance right is not easy, but it is a must to keep the Agency and international cooperation going.

Q: You and the IAEA were awarded the Nobel Peace Prize in 2005. What effect did that honour have on the Agency, and on your own work as Director General?

M.E.: The award represented a recognition of the hard work of all of the staff of the Agency. I am immensely proud of all of them, of their professionalism and commitment to the Agency's mission. Everyone likes recognition for exceptional achievement and I believe our staff have taken even more pride in their work since we got the Nobel Peace Prize.

For myself, the award was a clear validation that we were on the right track and should continue doing what we were doing, for the common good of humanity, and not be sidetracked by subjectivity, short-sightedness or cynicism. You may remember that it came at a time when we had all been under particularly intense pressure. I suppose you could say it represented vindication of our work in the court of public opinion. It gave us great visibility and made us a household name throughout the world. That visibility and trust in our integrity gave us greater moral authority to continue "speaking truth to power" and the courage not to be deflected from the core values and principles of the Agency — professionalism, independence, objectivity.

Q: You are leaving the IAEA at a time when a number of crucial issues are taking shape: a proposal for a low enriched uranium reserve under IAEA auspices to guarantee assurance of supply; the threat of nuclear proliferation at a time when the international community is preparing for the 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT); a possible expansion in nuclear power on a global level. What role can the IAEA play in dealing with these issues, and how are they going to affect the IAEA as an institution?

M.E.: The world is going through a major transition in terms of challenges and opportunities, the way it organises itself and the values it seeks to live by. As for the Agency, it too faces huge challenges, but also great opportunities. Scores of countries have told us they are considering introducing nuclear power. That will mean a major increase in the Agency's workload in technology, verification, safety and security. Our colleagues in Nuclear Energy are already increasingly focussed on helping what we call "newcomers" to ensure that, if they decide to build power reactors, they do it in a responsible manner.

In technical cooperation and development, demand for our assistance in human health, water, agriculture and the environment — to name but a few areas — will continue to grow. We need to focus more on being a multiplier — helping countries train specialists in nuclear medicine or what have you — and less on supplying equipment, important though that is. In other words, as the saying goes, we should provide fishing rods and not fish in order to make development sustainable.

There have been exciting developments in the nuclear disarmament field, so much so that I leave office with a greater sense of hope probably than at any time in the past 12 years. Nuclear disarmament is back on the agenda and there is a real possibility of major cuts in the arsenals of the nuclear weapon states and concrete steps to move us towards nuclear disarmament. It would be a natural development of the Agency's work to take on the verification role for many of these arms control measures.

> **"Scores of countries have told us they are considering introducing nuclear power. That will mean a major increase in the Agency's workload in technology, verification, safety and security. "**

Q: You have raised the vision of a nuclear-free-world in many of your statements. What roles can the IAEA play in the future to bring that vision into closer view?

M.E.: The NPT was developed in 1970. Its goal — and this is often forgotten — is a world free of nuclear weapons. That means that no more States should acquire such weapons, but also that the nuclear powers should disarm. Obviously, we are a long way away from that. Nevertheless, the NPT has been successful to an extent in limiting the spread of nuclear weapons. The fact that nine countries have nuclear weapons is nine too many — but it is a lot less than the several dozen which President Kennedy worried about in the early 1960s.

Nevertheless, the world has changed considerably since 1970. Nuclear technology was once thought to be the preserve of a few developed countries, but we have seen how it could be acquired with remarkable ease by other countries. A growing number of countries are what I call "nuclear weapons capable" — they have mastered uranium enrichment or plutonium reprocessing, which means they could manufacture nuclear weapons within a few months if they chose to due to changes in their security situation. We have also, most disturbingly, seen a thriving clandestine network trading in nuclear technology which has dramatically increased the risk of nuclear terrorism — in my view the number one threat the world faces today.

We therefore need to completely rethink the entire nuclear order. And the big nuclear powers must take the lead by moving seriously to divest themselves of their nuclear weapons. As President Obama rightly points out, only by taking serious steps towards disarmament will the weapon states acquire the "moral authority" to expect the rest of the world to refrain from ever acquiring nuclear weapons. The failure of the weapon states to demonstrate a serious commitment to achieving nuclear disarmament — an obligation which they took on under the NPT — has led to a worrying cynicism about the non-proliferation regime among many non-nuclear-weapon states that has made the regime inadequate and fragile in many respects.

For a long time it was fashionable to regard advocates of nuclear disarmament as naïve idealists. People thought "it can never happen." For many years, I felt like one of a few lonely voices, blowing in the wind. So I have been greatly encouraged in the last few years to see prominent Cold War statesmen and strategists such as Henry Kissinger, Sam Nunn, and many others, come to the conclusion that nuclear weapons are a grave threat to us all and that the only solution is to scrap them completely. I do not under-estimate the difficulty of getting to zero and we need to start working now on a security system that does not depend on nuclear weapons. But the fact that hard-headed veteran statesmen, and current leaders such as Barack Obama, Dmitry Medvedev and Gordon Brown, now see this as a necessary goal gives me hope that it might happen in my children's lifetime, if not in mine.

We have succeeded in largely eliminating chemical and biological weapons, so doing the same for nuclear weapons should not be beyond us. I am gratified that nuclear disarmament has become a mainstream agenda item again. As I have said many times, without disarmament, nuclear non-proliferation is not sustainable because any regime has to be based on fairness and equity.

Q: A big issue facing the international community comes from the spectre of terrorism, of threats from non-State actors. Do you see States granting the IAEA a bigger role when it comes to matters of nuclear security and prevention of terrorist acts?

M.E.: Nuclear security is primarily the responsibility of Member States, but it is clear that no country can address terrorism on its own and that coordinated and cooperative international action is needed. This is natural territory for the Agency. The 9/11 attacks demonstrated the sophistication of terrorism, of extremist groups. I am pleased with the speed with which the Agency built up a major nuclear security programme in the wake of those attacks. We have helped to ensure that radioactive sources and nuclear material have been made much more secure in many countries, but much remains to be done. The risk of a terrorist group exploding a so-called dirty bomb in a major population centre is very real and we cannot rest on our laurels. We still get several hundred reports every year of thefts or other unauthorised activities involving nuclear or radioactive materials. Most of the material that goes missing is never recovered. So we cannot afford to slacken in our efforts. I believe the Agency's role in helping Member States to guard against the threat of nuclear terrorism will inevitably continue to grow.

Q: Do you think that the IAEA's initiatives in development and cooperation are proving to be effective in dealing with the challenges posed by today's world?

M.E.: I believe we do very effective work in the development area, but it is much too little compared to the needs of developing countries. I am immensely proud, for example, when I see cancer patients in Africa getting access to nuclear medicine, radiation therapy and other methods of cancer control thanks to the work of the Agency. To touch even a handful of lives in the way we can is a wonderful thing. But I am simultaneously saddened by the realisation that what we are doing is only a drop in the ocean — that for every human being whose life is saved or prolonged by early diagnosis and treatment, countless more will never have access to it. Something is clearly wrong in a world where we always seem to be able to find the money for ever bigger and nastier weapons, but funding is mysteriously unavail-

An Extraordina

able when it comes to providing food, education and health care to the billions of our fellow human beings who live in sub-human conditions, in misery and despair.

But that's just one area. In nuclear power, we are the main vehicle for technology transfer to the developing world. Most of the new countries considering introducing nuclear power are in the developing world and we have highly specialist expertise to offer them. They are queuing up for our assistance in assessing their energy needs and we help them to embark on the long and complex road to building a power reactor — if that is the path they choose. It is not our job to lobby for nuclear power. Indeed I often have to tell countries "you are just not ready for this." But if a country makes the sovereign decision to proceed, the Agency will be there for them.

I should add that we must continually strive to make our technical cooperation projects in all areas as effective as possible and ensure that they meet the real needs of recipients. Frankly, countries' priorities are not always what we think they are. We need to get closer to the recipients. At the moment, we are looking into whether it might make sense to establish a number of regional IAEA field offices. I have always believed that we should focus on doing fewer but larger projects with real impact. We should also be quicker in terminating projects which have outlived their usefulness.

Q: Of all the things you have set out to do as Director General, what accomplishment or initiative do you think will be the most lasting?

M.E.: It is for others rather than me to assess the accomplishments of the last 12 years. And of course any accomplishments are those of all Agency staff, not just of the Director General.

However, a number of things give me satisfaction, not least the fact that the Agency has managed to continue providing high-quality services to Member States in the fields of development and security despite many years of zero budget growth. And as a result, the IAEA has become one of the most prominent international organizations. We are highly regarded, and more importantly trusted, by the general public and by our Member States, as a competent, objective and efficient international institution. I believe we have given international organisations a good name and shown what they can achieve if properly empowered. We have also demonstrated, at times of crisis, the value of an international institution that is impartial and objective.

The way we implement safeguards has changed radically. The amount of material and the number of facilities monitored by our inspectors have grown steadily and we have successfully adopted new technologies such as remote surveillance, environmental sampling and satellite monitoring.

"One initiative which I hope will come to fruition in due course is my proposal to establish multinational control of the nuclear fuel cycle, starting with a low enriched uranium bank under Agency auspices."

We have created a nuclear security programme virtually from scratch in a very short time. We are at the heart of the global nuclear safety regime. Indeed our safety standards have recently been adopted by the European Union. We have helped to boost food production and secure sources of fresh water in developing countries through the use of nuclear techniques. And the Agency has been singled out for the quality and efficiency of its management practices.

However, to be fair, I should mention the downside. Our technical cooperation activities are still too small and too reliant on voluntary funding. Too many countries still do not have a comprehensive safeguards agreement or an additional protocol in force. Our legal authority and funding remain inadequate. It gets a little frustrating, to put it mildly, to have to jump through the same hoops at the start of every budget cycle to get minimum resources so we can do what we are asked to do in a credible manner. After a turbulent process this year, we recently managed to secure a budget increase of around 5.4%. Although this was exceptional among UN system organisations, most of whom are having to live with zero growth, it is still not sufficient for the Agency to keep up with its growing responsibilities. That means, unfortunately, that the budget discussions will continue in the years to come.

One initiative which I hope will come to fruition in due course is my proposal to establish multinational control of the nuclear fuel cycle, starting with a low enriched uranium bank under Agency auspices. I believe some such mechanism is essential to guarantee that countries which have, or are contemplating, nuclear power plants will have a secure supply of fuel to run their reactors. It should reduce or eliminate the incentive to acquire enrichment or reprocessing capabilities which could be misused to make weapons in a short period of time. Our ultimate aim should continue to be the universal multinationalisation of the fuel cycle.

There has been good support for this proposal by many countries, but many others remain distrustful. I hope an agreement on the merit of the proposal will emerge soon. What is primarily required is the building of bridges of trust among Member States. Once that is achieved, all the technical and legal issues can easily be resolved.

Q: What would you say are the challenges lying ahead for the IAEA? Is the IAEA equipped to deal with them?

M.E.: The most basic challenge will be to keep pace with the ever-growing demands from Member States for Agency services. As I said earlier, the Agency's workload is certain to increase as more and more power reactors come on stream in the coming decade. I could talk at length about the need to secure adequate funding. Suffice it to say that the Commission of Eminent Persons, which I established under the chairmanship of former Mexican President Zedillo to look into the future of the Agency, called last year for our budget to be doubled by 2020. It also recommended an immediate cash infusion of 80 million euros to fix our dilapidated infrastructure. I sincerely hope that Member States will come to understand that this goal must be achieved if the Agency is to continue to fulfill its mandate.

The problem of human resources will become more acute. We are already having trouble replacing nuclear engineers and scientists approaching retirement. There are simply not enough highly trained young people coming out of the world's universities. And we will have growing difficulty in persuading graduates to work for the Agency rather than take up possibly more lucrative positions in the private sector. Agency rules do not always make it easy to attract the best talent.

Another key challenge will be to maintain the Agency's independence and objectivity, which are vital for our credibility. That is easily said but not so easily done. The Director General can come under enormous pressure at times to say what some Member States or others would like him to say — about the nature of a particular country's nuclear programme, for example. It is imperative that the Agency should resist such pressure and stick to the facts. The Agency's verification reports could make the difference between war and peace. Every word must be weighed carefully and we must never depart from the highest standards of impartiality and objectivity. Throughout my tenure, I insisted that the Agency must adhere to certain basic principles, in addition to objectivity and impartiality, which in my view have been the key to our success: fairness, due process and independence.

You ask if the Agency is equipped to deal with the challenges. Well, in addition to adequate, stable and predictable resources, the Agency also needs sufficient legal authority to do its job properly. Comprehensive safeguards agreements plus the additional protocol should become the norm. We also need the technology for environmental analysis and satellite monitoring, among other things, in order to ensure our independence.

I hope that all Member States will join the safety and security conventions and adhere to all Agency standards. Our system of peer reviews — in which, for example, countries submit their nuclear safety systems to scrutiny by experts from the Agency and other countries — has proved immensely valuable. Experts and practitioners share experiences and best practices and everyone benefits. Peer reviews are voluntary at the moment, but I see no reason why we could not move towards making them binding in due course.

Q: What would you like to say to the staff of the Agency as your term draws to an end?

M.E.: I would like to say that it has been an honour and a privilege to work with such talented and dedicated colleagues. All the staff have to pull together to make things happen — it is not just a single individual or group, it is always team work. I wish I had had the time to get to know every member of staff, particularly those whose work is less visible. But I should reiterate one last time that I have greatly valued the dedication and commitment of every single one.

The UN's High-Level Panel famously described the work of the Agency as an "extraordinary bargain." For me, working here for the past quarter century has been an extraordinary and enriching experience which I will continue to treasure.

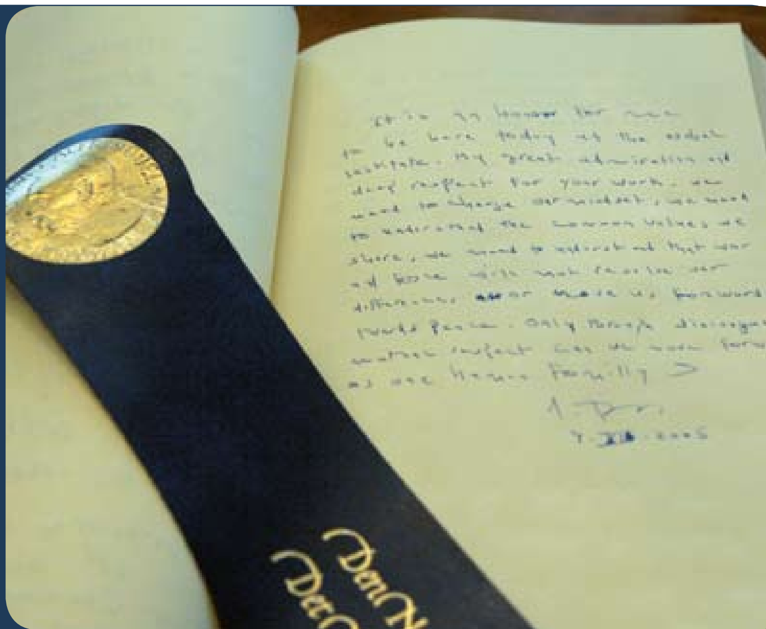
Giovanni Verlini is Editor of the IAEA Bulletin. E-mail: G.Verlini@iaea.org

12 Years at the Helm

Dr. Mohamed ElBaradei, IAEA Director General, 1997-2009

From Top: Dr. ElBaradei with members of staff of the Chinese Institute of Atomic Energy (China, December 2006. Photo: IAEA); Planting a sapling at the Kenya Agricultural Research Institute (Muguga, Kenya, 24 July 2009. Photo: K. Aning/IAEA); Visiting the IAEA's radiation monitoring and protection services laboratories (Vienna, Austria, 21 November 2008. Photo: D. Calma/IAEA); Checking progress at the IAEA's largest-ever Technical Cooperation programme in Vinča, Serbia. (Vinča, Serbia, 2 July 2009. Photo: IAEA)

On 10 December 2005, the IAEA and Mohamed ElBaradei jointly received the Nobel Peace Prize "for their efforts to prevent nuclear energy from being used for military purposes and to ensure that nuclear energy for peaceful purposes is used in the safest possible way." At the ceremony in Oslo, Dr. ElBaradei was awarded the Nobel Peace Prize together with Ambassador Yukiya Amano, who as Chairman of the IAEA Board of Governors in 2005-2006, accepted the prize on behalf of the IAEA. (Oslo, Norway, 10 December 2005. Photos: D.Calma/IAEA)



Under the watchful gaze of previous Nobel winners, Dr. ElBaradei inscribes the Nobel Peace Book.
It reads: ***"...We need to change our mindset, we need to understand the common values we share, we need to understand that war and force will not resolve our differences or move us forward to peace. Only through dialogue and mutual respect, can we move forward as one human family."***

(Oslo, Norway, 10 December 2005. Photos: D.Calma/IAEA)

Over the years, Dr. ElBaradei reported regularly to the IAEA Board of Governors on the Agency's work in the fields of nuclear safeguards, technical cooperation, and nuclear safety and security.
(Vienna, Austria. Photos: D.Calma/IAEA)

From top left:

- Dr. ElBaradei and his wife, Aida, with HSH Prince Albert II of Monaco (Monaco, 15 December 2008. Photo: Prince's Palace of Monaco);
- With King Carl XVI Gustaf and Queen Silvia of Sweden during their state visit to Austria. (Vienna, Austria, 21 November 2007. Photo: D. Calma/IAEA);
- Conferring with the then UN Secretary-General Kofi Annan at the 2004 UN Chief Executive Board (CEB) Forum. (Vienna, Austria, April 2004. Photo: IAEA);
- Giving an interview to Ghassan Sherbel, Editor-in-Chief of the Al-Hayat newspaper. (Vienna, Austria, 2009. Photo: D.Calma/IAEA); and
- Meeting a group of IAEA interns. (Vienna, Austria, 15 July 2009. Photo: D.Calma/IAEA).

change at the top

Ambassador Yukiya Amano of Japan was formally appointed as the next IAEA Director General on 3 July 2009.

Ambassador Amano, whose term as Director General would begin 1 December 2009, will be the fifth Director General of the IAEA in its 52-year history.
(Photos: D.Calma/IAEA)

"It is a great honour for me to address the Board today to express my heartfelt gratitude for the trust that you have placed in me, by appointing me to the post of Director General of the Agency. I would like to thank the Chairperson of the Board, Ambassador Feroukhi, for her sincere efforts and the tireless dedication she has shown in moving the process forward throughout this intensive period, leading to where we stand today. Your guidance and your efforts, Madam Chairperson, which you have conducted in a transparent, skillful and impartial manner, have greatly helped to render this a smooth process.

From the very beginning of my electoral campaign to this day, I as a candidate, have tried my best to secure support across the regions and different groups, and to take into consideration, without bias, the interests of all Member States. Today, I promise again that I will devote my every effort to the effective, efficient and impartial functioning of the Agency, in the interest of all Member States.

The efforts of a Director General can only be successful when they meet the needs and desires of the Member States. I promise to further intensify communication with Member States, while appealing through you, Madam Chairperson, for the continued cooperation and support of all Member States when I move to my new role at the helm of the Agency, following approval by the General Conference. The tasks awaiting us will be tremendous, but I am confident that a Director General who is trusted fully and actively supported by all Member States will not fail to achieve the goals enshrined in the Statute.

I had the honour to address the Board on 4 March and 26 May to explain my views as a candidate for the post of Director General. I will further elaborate on my thoughts and ideas over the coming months, but let me briefly highlight some of the key points. I will dedicate my efforts to the acceleration and enlargement of the contribution of atomic energy to peace, health and prosperity throughout the world. I will work towards the enhancement of technical cooperation and its related activities, the prevention of the spread of nuclear weapons, and the further improvement of the overall management of the Agency.

As a result of the immense efforts, commitment and time that Dr. ElBaradei has devoted to the Agency since his appointment as Director General in 1997 and also beforehand, the Agency has become the broadly celebrated and eminently decorated organization that it is today. I think I speak for us all in expressing my deepest gratitude to Dr. ElBaradei and his predecessors, for their contributions to the Agency over the years. I would also like to pay tribute to the staff of the Agency. They are the AgencyÆs most valuable asset, and their technical expertise, professional integrity and devotion to the Agency are indispensable in the fulfillment of the AgencyÆs mission. I am very excited and proud to be able to work together with these talented individuals, and to tackle new and outstanding challenges that the Agency faces, together, as a team.

Last but not least, I was truly honoured to have been running for the position of Director General alongside such highly-esteemed, competent and capable candidates, notably Ambassador Minty. I was particularly impressed by the professional and graceful manner in which all of the candidates ran their electoral campaigns. We now need to look to the future, and work, as a collective and united group of Member States, to achieve our common goals and the objectives set out in the IAEA Statute. I greatly look forward to listening to, discussing and cooperating with all Member States, and to working together closely to secure the further development and success of the Agency and its activities.

I would like to conclude my remarks by thanking you again for granting me this great honour. I pledge to serve the IAEA to the best of my ability, in an impartial and professional manner, and to dedicate myself fully to its honourable causes."

Statement by Ambassador Yukiya Amano at the IAEA Board of Governors Meeting of 3 July 2009.

"Today, I promise again that I will devote my every effort to the effective, efficient and impartial functioning of the Agency, in the interest of all Member States."

The Fifth DG

Ambassador Amano, 62, is the Permanent Representative and Ambassador Extraordinary and Plenipotentiary of Japan to International Organizations in Vienna, and Governor on the IAEA Board of Governors.

A graduate of the Tokyo University Faculty of Law, Mr. Amano joined the Japanese Foreign Ministry in April 1972.

Mr. Amano has held increasingly senior positions in the Japanese Foreign Ministry, notably as Director of the Science Division, Director of the Nuclear Energy Division and Deputy Director General for Arms Control and Scientific Affairs. He was appointed Director-General for Arms Control and Scientific Affairs in August 2002 and Director-General of the Disarmament, Nonproliferation and Science Department in August 2004.

Mr. Amano has extensive experience in disarmament, nonproliferation and nuclear energy policy and has been involved in the negotiation of major international instruments such as the NPT extension, the CTBT, the BTWC verification protocol, the amendment of the CCW and the ICOC. He represented Japan as a Governmental Expert on the UN Panel on Missiles in April 2001 and in the UN Expert Group on Disarmament and Nonproliferation Education in July 2001.

He has served in the Embassies of Japan in Vientiane, Washington and Brussels, in the Delegation of Japan to the Conference on Disarmament in Geneva and was Consul General of Japan in Marseille in 1997.

Ambassador Amano is to become the fifth Director General of the IAEA in its 52-year history. He will succeed Mohamed ElBaradei, who was first appointed to the office effective December 1997, and reappointed in 2001 and 2005. Other former IAEA Director Generals were Hans Blix, from 1981 to 1997; Sigvard Eklund, from 1961 to 1981; and Sterling Cole, from 1957 to 1961.


1957
2007
Atoms for Peace


P. Pavlicek/IAEA

One World, One Health

by David Nabarro

The links between animal and human health are clearly emerging.

There is widespread concern among governments, farmers' organizations and civil society groups, that too many people are unable to enjoy the right to food and nutrition, to have the wherewithal to feed themselves and their families, and to be resilient in the face of economic shocks, climatic events or acts of violence. The UN Secretary General is deeply concerned that food insecurity and hunger are being experienced every day by at least one billion of the world's inhabitants. That is one person in six, or 14% of the global population, with a child dying of malnutrition every six seconds.

Improving Performance

Unhealthy animal rearing practices in small and medium scale commercial operations can affect all who earn their living from animal rearing, especially those who keep a few animals in their backyards. They can also undermine the prosperity of the whole livestock sector, one which is growing at an extremely rapid rate. The prompt diagnosis of, and response to, diseases in animals is vital both for disease control and for assessing practices that are most likely to result in risks to animal health. This, in turn, is important not only for those who rear animals but also for the wider population given the importance of animal illness as a source for emerging disease in humans. At least two new pathogens capable of harming humans emerge each year, and 75% of these come from the animal kingdom. Frequently we do not know the potential pathogenicity of such an organism when it first emerges.

Within the United Nations System High Level Task Force for Global Food Security we work with nations as they contribute to national, regional and global partnerships for agriculture, food security and nutrition. We seek to help farmers and end users mobilize and improve access to the resources that are necessary to initiate and sustain improved production, with financial coordination mechanisms that gives them a better chance to access the investments they need in an integrated rather than piecemeal manner.

We will be guided in our work by the extent to which we are able to demonstrate reduction in hunger and poverty through improvements in production, agriculture related income, and the contribution of agricultural systems to mitigation of and adaption to climate change.

Influenza Viruses

During the last few years we have witnessed the agreement and application of important standards for animal and human health to the trans-boundary threats posed by disease — the World Organisation for Animal Health (OIE)'s animal health standards and the Revised International Health Regulations (IHR 2005) developed by member states of the World Health Organization (WHO). The IHR, for example, is an important intergovernmental framework and rules for collective responses to infectious disease. The proper implementation of the IHR 2005 depends on the full participation of national authorities and other stakeholders. Some of them question the extent to which systems for global governance on health reflect the interests of poor people and their nations: they question the value of globalized thinking and working.

During 2005 there was broad agreement on the scientific basis of work being undertaken on avian and pandemic influenza: outstanding research questions were also clear. These include a better understanding of risks associated with the movement of highly pathogenic avian influenza among poultry (particularly in ducks); the relative roles of wild birds, trade, and cross border movements in spreading H5N1 among birds; however the behaviour patterns that increase risks for human infection still needing some work.

WHO, Food and Agriculture Organization (FAO) and OiE had established clear strategies for national actions to be undertaken: stamping out Highly Pathogenic Avian Influenza (HPAI) when identified — through quick and thorough action; reducing the threat to poultry by introducing biosecurity; monitoring wild birds and charting their movements so that where possible wild birds that might be infected with this virus could be separated from domestic birds; reducing the risk of sporadic human cases by limiting the degree to which humans would be in contact with infected birds, and preparing to contain and mitigate the next influenza pandemic when it happens.

The challenge was to ensure that governments gave these strategies the impetus necessary for their implementation, leading to the control of HPAI and preparedness for an influenza pandemic. The technical work had to be taken forward within the momentum of the emerging political environment. As well as ASEAN, the US, the EU, Canada and Japan took political initiatives.

Within the UN system Influenza Coordination Office we helped align the work of different international institutions — including the World Bank, the international organizations of the UN, the regional development banks, other international, regional and local research bodies and so on — and to encourage the collective pursuit of international norms and standards, with the specialized organizations (WHO, FAO and the OIE) charting a path for the rest of the UN system and the myriad of other organizations becoming engaged in work on avian and pandemic influenza.

From the start, most of those who were involved in this work demonstrated unity of purpose and synergy of action. In general, coordination between the bilateral donors, the foundations, national governments, regional bodies and international non-governmental groups (including the Red Cross movement) was strong.

We have subsequently sought to identify the incentives that brought many disparate groups to work together. Finance was important, and the partnership has mobilized over US$ 3 billion in assistance for avian and human influenza actions between 2005 and 2009. But this — on its own — cannot explain the extent to which national authorities have worked together on these issues. The funds that have been pledged are primarily made available to governments: these have moved comparatively slowly.

An International Partnership on Avian and Pandemic Influenza was established as a basis for this cooperation. Other partnerships were organized at regional level through the EU, APEC, ASEAN and other regional groupings. Few of these partnerships were formal: most had real impact on the alignment and ways of working of their members.

We concluded that most of the groups working together on this issue recognized the value of working together, in synergy. They found it both operationally useful, and reassuring, in a situation where there was considerable political urgency and need for concerted action by institutions. Stakeholders from the public, private and voluntary sectors have valued the opportunity for coherence, working jointly and participation. They have worked together on disease surveillance, reporting and response. They have joined together to support the evolution of an inclusive movement that enables hundreds of different stakeholders to feel at home within it.

Pandemic preparedness work has moved forward over the last four years thanks to the efforts of this broader movement, and the effort has been tracked through annual global progress reports using information from participating countries. The reports, which have involved the full range of UN system agencies and the World Bank, have served as the basis for collective accountability. The reports reveal that over the four year period, there has been more rapid reporting of HPAI and more effective, sustained responses to outbreaks of the disease in poultry. The OIE is now pursuing the elimination of H5N1 in the next few years. There has also been a massive effort to initiate pandemic preparedness work which we believe has stood us in good stead as the world faces up to the first outbreak — potentially pandemic — of a novel influenza virus of this century.

Our annual reports identify seven factors critical for success. These are:

- consistent political commitment;
- resources and capacity to respond rapidly and effectively to a threat;
- interdisciplinary work (particularly animal health and human health) within countries and across borders;
- predictable, prompt, fair and sustained compensation schemes for those who lose property or animals as a result of control measures;
- strong engagement of public and private sectors and voluntary agencies;
- clear communication of reliable information (and sharing of uncertainty as appropriate); and
- a viable and scientific response strategy.

Experiences with SARS and other diseases suggest that if information is kept from people they will not feel empowered to be part of the response.

What are the incentives for success? First is the availability of good quality and accessible information about HPAI outbreaks — based on good mapping of issues, tracking of progress and risk analysis. The information that is available has been synthesized and made available to those who need it through the efforts of international organizations in response to the needs of their primary clients. Without well functioning surveillance and reporting systems we are stuck: OIE and FAO have played a major role, working with the support of a number of member states to establish better diagnostic surveillance and reporting capacity. The IAEA is probably not well known for the work that it does to help develop methods for measuring and detecting either virus or antibodies in animals and humans. There is a great deal of work that is being done as a result of the standards that are set and the methods that are developed through the IAEA.

A second incentive is the ready availability of instruments, services and assets needed for effective action. These include the Global Outbreak Alert and Response Network (GOARN) in WHO, or the FAO-OiE Crisis Management Center for Animal Health, that provide a backbone for solidarity and international action. This encourages countries and other stakeholders to be engaged — they know that dependable systems exist that can help them.

> "The IAEA is probably not well-known for the works it does to help develop methods for measuring and detecting either virus or antibodies in animals and humans.
>
> The cooperation among the IAEA, FAO and OIE is a reflection of the fact that these organisations have been working together in a very intense and productive way trying to get better systems for the production of healthy animals. Areas of cooperation include how to control new diseases that are emerging, trying to make sure that they are quickly detected and then managed in the most appropriate way, and how, at the same time, make sure that there is production of safe and continuous supply of food.
>
> Another focus is also how to link together the different research groups that are involved in trying to make sure that these food systems work to the advantage particularly of poor people in our world."
>
> *— D. Nabarro speaking at the opening of the FAO/IAEA Symposium on Sustainable Improvement of Animal Production and Health held from 8-11 June 2009 in Vienna, Austria.*

A third incentive is the existence of the right legal codes (and means for enforcement) at country level — for controlling movements of animals, for ensuring compensation when animals have to be killed and for enabling the consistent nationwide implementation of public health functions.

A fourth incentive is the widespread appreciation, among the public, of the pandemic threat and the need to be prepared. Unfortunately it has not proved easy to sustain the appreciation that animals, and ways in which they are cared for, can pose a risk not only for their own health but also for human health. The risk can be reduced by changed behaviour. The information and compensation needed to encourage such changes are often not sufficient. It is vital that the potential for animals to serve as the source for diseases in humans, and vice versa, result in better attention to the animal-human health interface — what we tend to refer to as the One World, One Health movement following the groundbreaking work of the wildlife conservation movement.

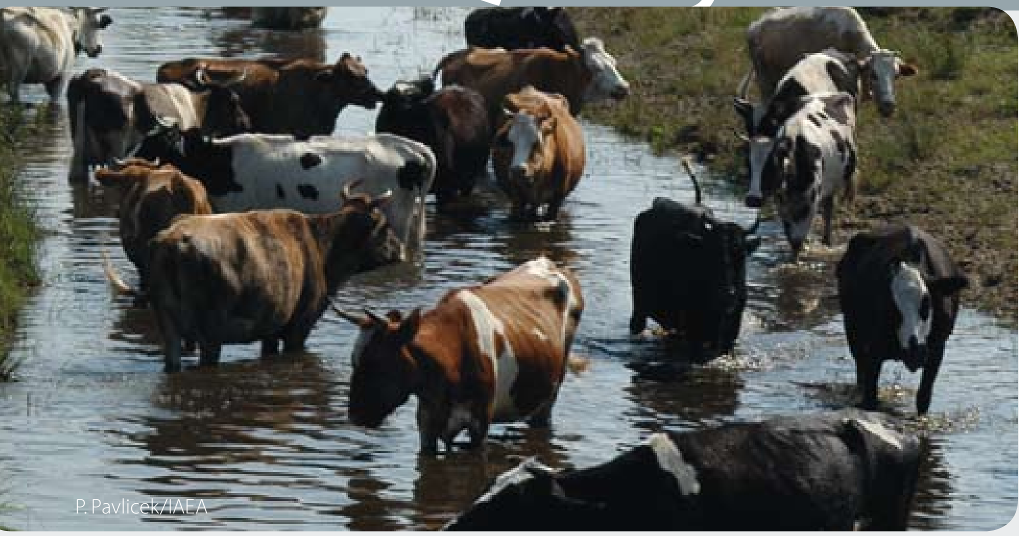
A fifth incentive is empowered and professional administration — people in government who feel that they are in a position to take the initiative in the face of a disease threat. They sometimes do not believe that their own authorities, or international authorities, are working to support what they seek to achieve. This is a challenge. H5N1 — or other diseases — will not be controlled through compulsion and sanctions. It does not work. People start to hide, they do not explain: they do their best to avoid involvement. So it is absolutely essential to build the necessary trust for effective action.

There are a number of continuing challenges for our collective effort to control HPAI caused by the H5N1 virus and to prepare for pandemics.

The first is the continuing lack of adequate systems and capacities for data collection and surveillance, laboratory services, and analysis, and for the management and use of information derived from the data. This applies to both animal and human health.

The second is the reality that some key groups (in some countries) are not fully engaged into the movement for pandemic preparedness. How to ensure that those who run the poultry industry in a HPAI-affected country see it as in their collective best interest to work together with the veterinary services, NGOs, researchers, and governments on control and prevention of HPAI? This requires a

Better Quality Beef and More Milk



P. Pavlicek/IAEA

Cattle breeders are now able to screen and select cattle for specific features, such as the ability to produce high-quality milk or resist specific diseases. After six years of work by more than 300 researchers from 25 countries and $53 million in funding, in April scientists were finally able to reveal the genome of the cow - the first mapping of the genetic composition of a mammalian livestock animal ever completed, providing crucial information about the evolution and biology of cattle.

According to researchers at the Joint FAO/IAEA Division of Nuclear Applications in Food and Agriculture, who participated in the cattle genome study, this research is expected to provide breeders and farmers with the opportunity to address the issue of achieving efficient and sustainable food production for a rapidly increasing human population.

"This study is a first of its kind in the world," says Gerrit Viljoen, who heads the Animal Production and Health (APH) Section of the Joint FAO/IAEA Division.

"By looking at the bovine genome we will be able to select for features that cattle breeders want in their cows, for example, better quality beef, more milk or disease tolerance/resistance and understand the genetic basis of the evolutionary success of ruminants which will provide opportunities to address some of the crucial issues of the present time — efficient and sustainable food production for a rapidly increasing human population."

The cow genome characterization study was conducted through two projects: the Bovine Sequencing Project and the Bovine HapMap Consortia Project — a HapMap is a map of genetic diversity among different populations of the same species. Funding for these projects was provided by an international group that included the IAEA through the Joint FAO/IAEA Division.

Nuclear techniques were also extensively used in the study and technical officers from the APHS contributed to data analysis and annotations.

continuous effort to build and sustain a movement. Movements wither away if they are not persistently supported and kept going.

The third challenge is to maintain trust through fostering action networks. For example: committed professionals from countries in South East Asia worked with the Rockefeller Foundation to build Mekong Basin Disease Surveillance Program over many years. This covers several different disease issues. It has generated trust between technicians across borders, has survived and continues to do well, despite occasional difficulties at the ministerial or high political level. Similar systems are being established between Bangladesh, India and Nepal following their HPAI outbreaks in 2008 and 2009.

We are all involved in this effort to build trust. We should ask ourselves, from time to time, whether we are contributing to trust as effectively as we could.

Conclusion

We need viable animal and human health services based on the best available technologies, and to be sure that the incentives are tangible. OIE's Performance of Veterinary Services scheme offers us some valuable pointers.

It is worthwhile getting the incentives right so that pandemic preparations are successfully put in place. The reward may well be that when the next severe influenza pandemic strikes, millions of people survive who might otherwise have been expected to die.

David Nabarro is UN System Coordinator for Influenza and Global Food Security. This article is an excerpt from a statement he gave at the International Symposium on Sustainable Improvement of Animal Production and Health, held on 8 June 2009 in Vienna.

through Nuclear Research

"Radioactive isotopes were used for labelling and characterizing the genetic information of the cow genome, a process known as radiolabelling of DNA," explains Viljoen.

Specifically, the Joint Division´s APH Section sponsored the study of Sheko breed, which is native to Ethiopia and is resistant to trypanosomosis, a disease transmitted by the tsetse fly, and has the ability to achieve good productivity under difficult environmental conditions.

It is hoped that the information obtained from the study can be a first step in the greater utilization of the Sheko and other related indigenous breeds to improve livestock productivity and the livelihoods of farmers.

The results of the bovine genome sequencing and characterization studies were published in the journal "Science".

Genome Sequencing

By determining the order, or sequence, of the structural units in a DNA molecule, genome sequencing helps scientists study biological processes and identify key genetic characteristics in the animal or plant being examined.

The Bovine Genome Sequencing Project identified, or sequenced, the complete genome of a female Hereford cow. The Bovine HapMap Consortia, on the other hand, described genetic variation among different cattle varieties, starting with the major division between the humpless taurine cattle most commonly found in Europe, Africa and East and West Asia, and the Bos *indicus* cattle found in India, South and West Asia and East Africa.

The researchers used the complete sequence from a single Hereford cow and comparative genome sequences from six more breeds to look for variations in DNA molecules (known as single nucleotide polymorphisms, or SNP) in 497 cattle from 17 geographically and biologically diverse breeds and two related species, the Anoa and the Water Buffalo.

Their studies indicate the cattle have a diverse ancestral population that has undergone a recent rapid decrease in effective population size, probably because of domestication, selection and the development of breeds.

The evolution of humans and cattle intertwined between 8,000 and 10,000 years ago, and today there are more than 800 cattle breeds selected for different economic, social and religious reasons.

The Bovine Haplotype Map is generating excitement because it offers the chance to select for features that cattle breeders want in their cows -in particular, high-quality milk. Until now, the only way to guarantee the best cow's milk was by taking a bull, inseminating cows with his semen, and then waiting for the female offspring to grow and produce calves and milk to feed them, at a cost of $25,000 to $50,000 per bull. (Most of the genetic improvements in the cattle industry come through males, because each male can produce tens of thousands of females.) Already, cattle breeders are eagerly mapping SNP in most of their bulls, with an eye toward identifying which SNP are linked with various desirable qualities.

(Photo: D. Calma/IAEA)

Improving Livestock Productivity in Honduras

by Rodolfo Quevenco

An IAEA project is set to move from laboratories to farm.

Honduras is poised to bring a set of integrated laboratory-based services for the benefit of cattle farmers, as an IAEA-supported project to improve livestock productivity moves into its third phase.

The project addresses two main areas. First, it directly assists milk and meat producers by determining the nutritional value of pastures, forages and potential cattle feeds; by reinforcing the sperm bank and selection criteria for cattle for higher meat and milk production; and by improving diagnosis of diseases affecting livestock. Secondly, the project also helps introduce new and laboratory techniques to ensure quality of the country's meat and milk products bound for export. The ultimate goal of all these activities is to improve livestock production in the country.

"In the first and second phases of the project, we concentrated on building the laboratory infrastructure," says Juan Carlos Ordoñez, the project counterpart at Honduras' "Servicio Nacional de Sanidad Agropecuaria (SENASA)" in the Ministry of Agriculture. The objective was to establish a strong basis for delivering a set of integrated services in areas such as genetic improvement, residue analysis, nutrition, health and reproduction.

Through assistance from international donors, including the IAEA, the laboratories operating under SENASA are well-equipped and efficiently dedicated to accomplish these tasks. Key IAEA contributions included a real-time PCR machine and equipment for the semen processing laboratory, which greatly boosted Honduras capabilities in disease diagnostics and livestock reproduction.

The Agency has also helped train key personnel in the use of these equipment, as well as in the practice of nuclear and molecular techniques including radioimmunoassay (RIA). RIA has been the dominant technology in the field of livestock productivity and one of the most common techniques being used in the IAEA project in Honduras. The technique employs radioisotopes to measure the concentration of a given molecule in a biological sample. For reproduction, the most commonly measured molecule has been progesterone.

“Measuring molecules like progesterone is important because it gives experts a much better understanding of the reproductive physiology of the animals,” according to Mario Garcia Podesta, consultant at the Animal Production and Health Section in the FAO/IAEA Joint Division of Nuclear Techniques in Food and Agriculture.

As the Section’s technical officer for Honduras, Garcia recently concluded a field review visit of the project and assessed the capabilities and future needs of the laboratories in light of project objectives.

“It is evident that SENASA authorities and laboratory directors play a key role in implementing new technologies to be more efficient and accurate in the results,” he said. Garcia recommends that, for the project’s next phase, more focus should be made on livestock productivity and direct technical advise to cattle farmers.

“In the third phase of the project, we intend to move out to the farms... strongly!” Juan Carlos Ordoñez emphasized. As a starting point, the project is relying on data provided through a sizeable database of up to 200 cattle farms. For this year alone, data on the production, reproductive and health status of livestock at 6-12 farms out of the 200 will be constantly monitored in an effort to suggest and implement better management practices. The network of diagnostic laboratories now in place in Honduras will play a key role in measuring the technical impact and economic benefit of these intervention efforts.

Improving livestock production is becoming more and more a priority among many developing countries, as diets shift from plant-based protein to animal-based protein. Also issues as diverse as nutrition, health, reproduction, animal disease and export controls mean that many countries face growing challenges to implement sustainable livestock productivity programmes. The IAEA currently have over 40 livestock productivity programmes in various stages worldwide which aim to help countries improve livestock productivity and health. From 8-15 June, an international symposium is taking place in Vienna that will examine the challenges and opportunities in livestock productivity, as well as the application of technologies, including nuclear-based ones, that would help to support sustainable livestock productivity in developing countries.

For countries like Honduras, livestock productivity has strategic macro-economic importance to the economic well-being of the country and for reducing poverty.

“In Honduras, there is a saying that livestock constitutes the savings of the country,” Juan Carlos Ordoñez explains. “Most rural families raise a pig or a small herd of cattle that, come December, they can sell for cash. Thus, it truly is an ‘alcancía’ (personal savings) of the country.”

Technical assistance from the IAEA has helped the livestock reproduction laboratory in Honduras to provide better cross-breeding services to local farmers. (Photo: D. Calma/IAEA)

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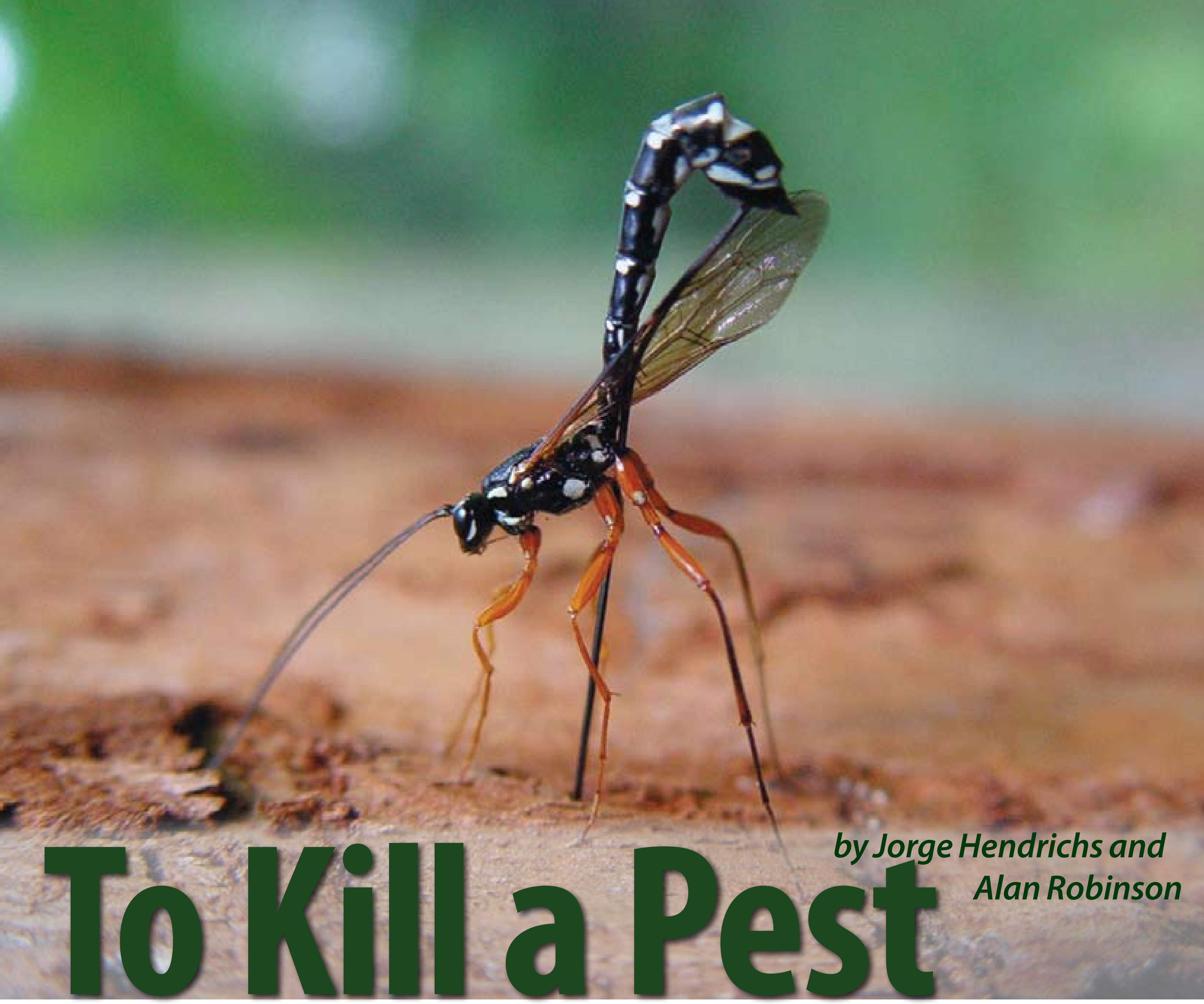

To Kill a Pest

by Jorge Hendrichs and Alan Robinson

The use of radiation is improving the biological control of insect pests.

A giant ichneumon wasp adult boring the surface of fir trunk infested with wood wasp larvae. (Photo: Boris Hrasovec, Faculty of Forestry, Bugwood.org)

The IAEA's support to Member States in the field of insect pest control has mainly focused on the Sterile Insect Technique (SIT), which is a type of insect birth control, where mass reared and systematically released sterile males of the target pest insect mate with wild females in the field, thereby interfering in an environment-friendly way with the reproduction of the pest population. This approach effectively reduces the use of insecticides and has been successfully used to manage, and in some cases eradicate, populations of major pest insects. Nevertheless, there are other areas where Member States can benefit from radiation in the field of entomology. One of these is biological control.

What is Biological Control?

Despite centuries of technological development, insect pests continue to exact a very high toll on agricultural production and human health. A well-established, successful approach to this problem is the use of natural enemies, called biological control agents, to manage pest populations. The biological control agent can be a predator, a parasitoid, a bacterium, a fungus or a virus. In this article we will concentrate on predators, which eat the pest (prey), and parasitoids, which parasitize the pest (host) by stinging and thereby laying eggs into it.

When insects escape their native natural enemies, either because they invade new countries leaving behind their biological control agents or as a result of the disturbance of these natural enemies, they become pests. As shown in Box 1, if appropriately applied, biological control offers one of the most promising, environmentally-sound, and sustainable tools for control of such insect pests. However, there are many constraints to the expansion of biological control programmes, related to the production, shipment and release of biological control agents. The commercial and public biological control industry is growing but still represents less than 3% of pest control sales. Regulatory, technical and other constraints have kept the market share relatively small. The challenges include the high cost of production, adequate quality control and assurance, trade barriers and regulations that complicate shipping.

There are several ways in which nuclear techniques can address these constraints and the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture has now completed a Coordinated Research Project on this topic with the participation of 18 research teams from 15 countries.

Regulating Biological Control Agents

Lack of international harmonization among countries and availability of enabling regulations is probably the most important barrier to the wider implementation of biological control, 'gatekeeper' regulations place barriers in the way of efficient introduction and application of biological control agents. However, the Secretariat of the International Plant Protection Convention, of the Food and Agriculture Organization of the United Nations (FAO) has published a revised International Standard for Phytosanitary Measures (ISPM) on 'Guidelines for the export, shipment, import, and release of biological control agents and other beneficial organisms', which should help to solve some of these problems and increase trans-boundary trade in biological control agents.

Safeguarding Biodiversity

At times, the biological control agent chosen to be released is an exotic species to the environment. One of the key concerns in this approach is the question of specificity of the biological control agent in its new ecosystem, i.e. will the introduced biological control agent remain associated with the pest or will it expand its range to impact on other species in the ecosystem and so affect biodiversity or even attack beneficial species or commercial crops? There are numerous examples where introduced biological control agents have 'jumped species'. Since such mistakes are permanent in time and space, the feasibility of such introductions need therefore to be carefully assessed before the introduction of any biological control agent is undertaken. One of the best-known of these mistakes is the cane toad in Australia, which was introduced to control pest insects in sugar cane, however, it very quickly began to feed on other species and multiplied in numbers until it became a pest itself. Once biological control agents are released, they cannot be recalled and, as they are fertile, they have the

Biological Control of the Cassava Mealybug

This insect became a devastating pest of cassava in Sub-Saharan Africa following its introduction into Congo from South America in the 1970s and its rapid spread to the rest of the subcontinent. Cassava is the prime source of carbohydrates, proteins and vitamins for 200 million Africans. A natural parasitoid (insert image) of the cassava mealybug was identified in Paraguay, the origin of the pest in South America, and transferred to the International Institute for Tropical Agriculture, in Ibadan, Nigeria where it was mass reared. It was released from over 150 sites in the region, became established and brought the pest under control in 95% of all fields.

Screening Exotic Biological Control Agents to Safeguard Biodiversity

- In the USA the field evaluation of an exotic herbivore in sterilized form, for the eventual biological control of the Brazilian pepper tree, a major weed that has been accidentally introduced.

- Also assessment of irradiated cactus moths, a pest of different native cactus plant in some locations, and a biological control agent of introduced cactus weeds in others, to confirm under natural conditions oviposition preferences to predict the host range, the ability of larvae to survive and cause damage on related native plants, as well as to study possible interactions with natural enemies.

Top: Mucidifurax raptor wasp on a fly puparium. Once the female chooses a suitable puparium host, she lays a single egg in it. The egg hatches, and the wasp larva feeds on the fly pupa.
(Photo: USDA ARS Photo Unit, USDA Agricultural Research Service, Bugwood.org)

Bottom: Braconid wasps: parasitoids on sphinx or hawk moths.
(Photo: David Cappaert, Michigan State University, USA. Bugwood.org)

opportunity to reproduce and increase in numbers. This is fine if they remain "locked onto" the pest species but can be disastrous if they find new non-pest hosts in the new ecosystem.

Radiation can play an important role in the safe evaluation of the potential host range of a biological control agent in a new ecosystem. It provides a way to sterilize and release biological control agents in the field without establishing them permanently and without affecting their behaviour, and to assess what they eat and do not eat, what hosts they parasitize, and where they go. Repeated releases of sterilized biological control agents will provide without risk critical information under natural conditions in order to improve decision making relating to eventual fertile release.

Improving Mass Production

As a biological control agent preys on or parasitizes another insect species, it follows that both species have to be reared in order to produce the biological control agent for release, in other words it is a two component biological system. This is in contrast to the SIT where only one species needs to be reared. This increased complexity makes the mass rearing of biological control agents logistically demanding and more expensive.

Often the natural prey or host species are themselves difficult or expensive to rear in large numbers and the use of more readily available substitutes would be an advantage – the so called factitious species. However, these types of species are not always as acceptable as the natural prey or host; this is especially the case for biological control agents which lay eggs in living hosts which are then subject to its immune response. Radiation can be used to suppress the immune response of the host making it more suitable for parasitism.

A host is often suitable for parasitism only within a very small window of time during development and radiation can be used to enlarge this window by reducing the speed of development of the host. The limited shelf life of hosts and prey also restricts their use during mass-production and for certain species radiation can be used to arrest development and thus allow for storage and stockpiling of hosts or prey to be used when required by the customers (farmers, greenhouses, grain mills, poultry houses, etc.).

Improved Mass Production of Biological Control Agents

- In Bulgaria, an irradiated factitious host used to rear the wasp that parasitizes moth pests in mills and grain warehouses.
- In Pakistan, irradiated moth eggs utilized as a prey substitute to feed a predator for area-wide control of cotton and sugarcane pests.
- In Poland, radiation used to successfully extend the shelf-life of parasitoids to control stored grain moths causing damage in grain warehouses.
- In Turkey, an irradiated factitious host used to mass rear a parasitoid of the olive fly for use in an area-wide pilot project in an olive production area.

There is also the use of the controversial phenomenon known as 'radiation hormesis', i.e. the use of very low doses of radiation to stimulate biological processes. There is some preliminary evidence that this process can increase parasitisation rates and reproduction.

Facilitating Handling, Shipment, Trade and Release

A major headache for producers of biological control agents is the continued development and emergence of some pest insects, in the form of non-parasitized hosts and unused prey insects, among the mass produced natural enemies. This "contamination" of the final biocontrol product can create major problems in terms of efficiency of the mass-production process. It requires additional handling steps involving the removal of significant numbers of non-parasitized hosts or unused prey individuals from the rearing process before they are shipped and emerge as pest insects with farmers using the biological control agents. Radiation can be used to sterilize prey, hosts, and factitious hosts to prevent further development of the pest insects and thus remove the need for labour intensive separation procedures.

When biological control agents are shipped to other countries, the fact that shipments often include fertile pests, either as prey or hosts, brings with it a real or perceived risk that this could lead to the introduction of non-native, pesticide resistant or new strains of pest insects into new areas or countries. This risk can be translated into ever more stringent quarantine regulations and permits required for their shipment. Irradiation of hosts and prey can ensure that, even if not all the hosts are parasitized and all the prey eaten, customers receive shipments free of fertile pest insects.

There is also the need to safely ship hosts and prey between different facilities; for example large production facilities may decide to ship hosts/prey to smaller satellite facilities which concentrate only on rearing the biological control agent and not the hosts or prey. This procedure can be made safe by irradiating the material before shipment as is now routinely done in SIT programmes, where sterile pupae are shipped to large emergence and release facilities. The use of radiation in this way will lead to increased efficiencies in the production of biological control agents and will help to standardize the use of strains of host/prey material to ensure product quality.

Supplementing Biological Control Agents in the Field

- In China, irradiated moths released into field crops where their sterile eggs served as hosts for wild parasitoids resulting in parasitoid population increase.
- In Czech Republic, irradiated moth eggs distributed in a natural forest to serve as hosts for wild biological control agents.
- In Czech Republic, sterile moth larvae deployed in forests to monitor the density and type of parasitoids and pathogens.
- In Pakistan, irradiated hosts placed in the field early in the season to increase populations of parasitoids to effectively manage sugarcane pests in an area of 40,000 hectares.

Handling, Shipment, Trade and Release of Biological Control Agents

- In Argentina, radiation of housefly pupae used to mass rear egg and pupal parasitoids for deployment in chicken houses and cattle feedlots.
- In Mexico, irradiation of immature stages of fruit flies to mass rear ca. 100 million fruit fly parasitoids each week, as part of the area-wide release of the parasitoids.
- In the USA, irradiation of prey for the production of predatory mites for the control of vegetable pests in greenhouses.

Supplementing Biological Control Agents in the Field

In the field, insect pests go through population cycles as do their biological control agents. Unfortunately these cycles are often not in synchrony and the biological control agent populations generally lag behind the pest populations. If the number of biological control agents could be increased prior to the increase in the pest population then much better control would follow. This can be achieved by distributing prey or hosts, sterilized by radiation, into the field early in the season so

Pink spotted ladybird predator feeding on eggs of Colorado potato beetle.

(Photo: Whitney Cranshaw, Colorado State University, Bugwood.org)

that the numbers of biological control agents can be safely built up on the pest insects deployed.

In biological control programmes it is necessary to monitor the biological control agent in the field to assess its population levels, survival, distribution etc., and this again can prove to be quite difficult as the numbers of hosts can be low in an effective programme. However, radiation sterilized hosts can be safely introduced into the target location as sentinels to increase the chance of correctly evaluating the presence and levels of the biological control agent and so increase programme efficiency.

Exploring for, and collection of, new exotic biological control agents in countries of origin can be a very difficult task as hosts can be rare or difficult to locate or both. Radiation sterilized hosts can be deployed in the field at strategic locations and so increase the chances of collecting new biological control agents.

Integrating Biological Control with SIT

Many years ago, the father of the SIT, E.F. Knipling, suggested that it would be advantageous to combine the release of sterile insects with the release of biological control agents. He suggested that a synergistic response in reducing the size of the target population could be achieved as the sterile males mate with the adult females in the wild assuring no offspring, whilst the biological control agents target the other developmental stages of the pest insect, i.e. the egg, larva or pupal stages.

Such an integration of sterile insects and other beneficial organisms has now been achieved in a number of crop and pest situations, and there is great potential to expand this integrated and fully environment-friendly biological approach.

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Integrating Biological Control Agents and Sterile Insects

In Mexico, sterile fruit flies and parasitoids released simultaneously as part of a large national campaign that has eliminated fruit flies from northwestern Mexico and suppresses them effectively in other areas.

In Syria, simultaneous releases of egg parasitoids and sterile moths synergistically reduced field populations of the potato tuber moth.

In South Africa, simultaneous releases of egg parasitoids and sterile moths synergistically reduced field populations of the false codling moth in citrus orchards. These findings have encouraged the establishment of a private company by the South African citrus expert industry.

In India, entomopathogenic nematodes released together with irradiated moths to control pests of cotton.

In Israel, by-products of insect mass-rearing used for the production of predators of greenhouse pests and parasitoids of houseflies.

Sustainable Nuclear Energy

by Y. Sokolov and R. Beatty

Assessment tools developed by the IAEA assist Member States in strategic planning and decision making on sustainable nuclear energy development and deployment.

Long-range and strategic planning for energy system evolution and the potential role of nuclear energy therein requires a sound understanding of the dynamics of technology change and innovation. Careful consideration of energy related infrastructures, social preferences, economic development directions and environmental constraints must be part of national nuclear energy deployment. Nuclear Energy System Assessment (NESA) is an integral part of national nuclear power development along with energy planning and nuclear infrastructure development using the IAEA 'Milestones' approach for first nuclear power plants. In particular, adopting a nuclear power programme has intergenerational implications and obligations extending well beyond 100 years.

Energy planning aims at ensuring that decisions on energy demand and supply infrastructures involve all stakeholders, consider all possible energy supply and demand side options, and are consistent with overall goals of national sustainable development. The decision that nuclear energy will be part of a diverse energy mix should include reactor technology selection, infrastructure development required for first plants, and an understanding of the entire range of impacts and considerations related to deploying a sustainable nuclear energy system. This must include innovations in nuclear technology and institutional arrangements that contribute to, and are caused by, global evolution.

A nuclear energy system encompasses the complete spectrum of the nuclear fuel cycle, i.e. from mining to final end states for all wastes, and associated institutional arrangements. Nuclear energy systems are characterized by complex infrastructures and long life, easily extending over several generations. In addition, developing or expanding nuclear energy requires extensive lead times and resources, especially for the design and commercialization of new and innovative components. Nuclear energy systems must be assessed holistically, i.e., from all possible angles of sustainable development, which includes three interdependent and mutually reinforcing pillars: social development, economic development and environmental protection, all linked by effective government institutions.

Nuclear Energy System Assessment using the INPRO Methodology

To assist Member States in assessing their long range strategic planning for existing or future nuclear energy systems, the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) developed the 'INPRO Methodology' with contributions from 300 international experts including some from the Generation IV International Forum (GIF). The Nuclear Energy System Assessment is a holistic approach that uses this internationally validated tool — the INPRO methodology — to support long-term planning and strategic decision making on nuclear energy development and deployment in Member States.

A prerequisite for a NESA is an energy planning study in case of newcomers — or a national energy strategy for countries with a mature nuclear power programme — that defines the potential role of nuclear in a mix of energy supply at the national level, however with due regard to regional and global trends. IAEA energy planning models assist energy planners in undertaking such studies. National authorities in charge of energy policy or nuclear energy system planning can initiate a full assessment or a scoping NESA.

A NESA with the INPRO methodology evaluates all nuclear facilities in a given nuclear energy system, from mining through to final end states for all

INPRO: A Partnership for Dialogue and Innovation

The IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) plays an important role in understanding the future development of nuclear energy systems from a national, regional and global perspective, and innovations in technologies and institutional arrangements in support of this development.

Established as a commitment of IAEA Member States to help ensure that nuclear energy is available to contribute to meeting the energy needs of the 21st century in a sustainable manner, INPRO brings together technology holders and users to consider jointly international and national actions that would result in required innovations in nuclear reactors and fuel cycles.

INPRO provides a forum for discussion and cooperation of experts and policy makers from industrialized and developing countries on all aspects of sustainable nuclear energy planning, development and deployment. It promotes a mutually beneficial dialogue between countries with nuclear technology and countries considering these technologies to develop new nuclear energy capacity. It also offers Member States support in national strategic planning and decision making on nuclear energy development and deployment, and enhances awareness of technology innovation options for the future.

IAEA Member States and recognized international organizations can become members of INPRO provided they make a contribution to the project. Contributions can be in the form of donating extra-budgetary funds, providing cost-free experts, performing assessment studies using the INPRO methodology or participating in INPRO collaborative projects.

Since its establishment in 2001, membership in INPRO has grown to 31 members. These countries represent 75% of the world's GDP and 65% of the world population.

Ten other countries have observer status as they consider membership or are participating on a working level. In addition, INPRO is collaborating with other international initiatives including the Generation IV International Forum (GIF) and the European Sustainable Nuclear Energy Platform (SNETP) to ensure good synergy and avoid duplication of effort.

Funded mainly by extra-budgetary contributions, the project now benefits from a recent commitment of the Russian Federation to provide resources for five years; this has added stability to the project and allows longer term planning. Recently, INPRO activities were consolidated into five main areas which also form the basis of the project's action plan for 2010 and 2011. Twelve collaborative projects sup-

wastes including permanent disposal of high-level waste, and all related institutional measures. It considers the complete lifecycle of nuclear facilities ('cradle to grave'), i.e. design, construction, operation and decommissioning, and evaluates a nuclear system in the seven areas identified by the methodology developers, which together encompass the dimensions of sustainable development: economics, infrastructure (institutional arrangements), waste management, proliferation resistance, physical protection, environment (impact of stressors, and resource depletion), and safety of reactors and of nuclear fuel cycle facilities.

Countries with established nuclear programmes, as well as nuclear 'newcomers' who are considering embarking on new nuclear programmes can conduct a NESA to identify possible gaps in their nuclear programme and associated actions to fill the gaps. This is targeted at:

❶ Nuclear technology developers, to assess their long-term development and deployment strategy to confirm that it is sustainable and that it has the correct balance of nuclear facilities;

❷ Experienced nuclear technology users, to increase the awareness of key stakeholders and assist with strategic planning and decision making concerning the expansion of their nuclear energy system;

❸ Prospective first time technology users, to identify issues that need to be considered when deciding the step by step development of a nuclear energy system, i.e. developing the necessary nuclear infrastructure and building a first nuclear power plant.

National Assessments

Recently, several countries performed a series of national NESAs: Argentina, Armenia, Brazil, India, Republic of Korea, and Ukraine. In addition, eight countries, i.e. Canada, China, France, India, Japan, Republic of Korea, Russian Federation, and Ukraine, port the activities with active participation of INPRO Members.

INPRO Programme Areas

Nuclear Energy System Assessments (NESAs) Using the INPRO Methodology

INPRO recently passed a milestone with the development and application of the INPRO methodology that can help countries assess existing and future nuclear energy systems in a holistic way and supports long-term strategic planning and decision making. After a first series of successful studies, eight additional countries have expressed interest in assessing existing or future nuclear energy systems to determine if they meet national sustainable development criteria.

Global Vision on Sustainable Nuclear Energy

By formulating potential scenarios and harmonizing visions for long-term global nuclear development and deployment, INPRO helps newcomers and 'mature' nuclear countries alike to understand the potential of technical innovations and of new institutional and legal approaches for developing and building a sustainable nuclear 'architecture' in the 21st century, including possible transition scenarios.

Promotion of Innovations in Nuclear Technology

Fostering collaboration among INPRO members on selected innovative nuclear technologies and related R&D, which contribute to sustainable nuclear energy, are key activities in this area.

Promotion of Innovations in Institutional Arrangements

In addition to the complete spectrum of the nuclear fuel cycle, institutional arrangements are also part of the nuclear energy system. Such arrangements include agreements, treaties, national and international legal frameworks or regimes, and conventions. Deploying new reactor designs may require innovative approaches to institutional measures, in particular for non-stationary, small and medium-sized reactors. INPRO fosters collaboration in this area and supports countries in developing and implementing innovative arrangements.

The INPRO Dialogue Forum

This cross-cutting area aims at fostering the information exchange between nuclear technology holders and technology users to ensure that future technical and institutional innovations meet the expectations of both.

INPRO members are Algeria, Argentina, Armenia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, the Czech Republic, France, Germany, India, Indonesia, Italy, Japan, The Republic of Korea, Kazakhstan, Morocco, the Netherlands, Pakistan, the Russian Federation, Slovakia, South Africa, Spain, Switzerland, Turkey, Ukraine, the United States of America and the European Commission.

www.iaea.org/INPRO

jointly investigated a nuclear energy system consisting of sodium cooled fast reactors with a closed fuel cycle (see box "Closed Fuel Cycle With Fast Reactors").

The national NESA studies were conducted by countries of both technology users and developers and included different scales of assessments. Argentina and Ukraine evaluated the sustainability of their planned national nuclear energy systems by assessing all facilities of the nuclear fuel cycle. Brazil, India and the Republic of Korea assessed specific reactor designs and associated fuel cycles in selected areas of the INPRO methodology. The Brazil team chose the IRIS reactor design and assessed it in the areas of safety and economics. In addition, the Fixed Bed Nuclear Reactor (FBNR) design was assessed for sustainability in the areas of safety and proliferation resistance. The Indian study investigated the replacement of fossil fuel by hydrogen in the transportation sector. The prime objective of the Korean study was to develop a qualitative analysis to determine the level of proliferation resistance of the DUPIC fuel cycle, where spent PWR fuel is transformed into new fuel for CANDU reactors. Armenia performed a NESA primarily to familiarize national decision makers with all issues of the planned nuclear power programme of replacing the existing reactor by a larger unit around 2025.

The Joint Study explored several possible scenarios through modelling of how different nuclear technologies could contribute to fulfilling the expanded role of nuclear energy and what kinds of problems and approaches might be considered to allow an easy transition to a closed nuclear fuel cycle with fast reactors.

INPRO methodology

The INPRO Methodology is organized in a three-tier hierarchy of Basic Principles, User Requirements and Criteria, consisting of indicators and acceptance limits. These elements are used in the seven INPRO assessment areas. An assessed nuclear energy sys-

Closed Fuel Cycle with Fast Reactors

Over a period of two years, eight countries joined forces to assess a nuclear energy system based on a closed fuel cycle with fast reactors (CNFC-FR) with the INPRO methodology. The objective of this "Joint Study" was to determine whether a CNFC-FR would meet criteria of sustainable development, to define milestones for deploying nuclear energy and to establish areas which would require future collaborative R&D work. The countries were Canada, China, France, India, Japan, the Republic of Korea, the Russian Federation, and Ukraine. A near-term CNFC–FR system based on proven technologies, such as sodium coolant, MOX pellet fuel and aqueous reprocessing technology was used as a reference system.

A general observation was made that an optimized future for nuclear energy deployment may not be entirely consistent with current national planning. With the goal of making the CNFC-FR a viable alternative to conventional sources of power, the Joint Study identified some weak points in current national approaches that must be resolved. This refers specifically to economics and safety, where further research is necessary to achieve a lower level of risk of severe accidents.

The design of currently operating nuclear energy systems with CNFC–FR may not meet economic competition requirements. Simplifying the design, increasing the fuel burn up and reducing costs through targeted R&D, along with small series constructions, could make the costs of nuclear power plants with fast reactors comparable to those of thermal reactor and fossil fuelled power plants.

In some countries, the introduction of fast reactors might contribute to an efficient use of nuclear fuel resources by increasing the use of plutonium fuels and denaturated uranium fuel, to be generated in the fast reactor blankets, if needed.

By developing and introducing novel technologies for an optimal management of nuclear fission products and minor actinides, the CNFC–FR system would have the potential for a 'breakthrough' in meeting all of today's requirements of waste management.

Due to the technological features of the CNFC–FR system, its proliferation resistance could be comparable to, or higher than that of a once-through fuel cycle. The CNFC–FR system is a key technology for the balanced use of fissile materials.

A CNFC–FR system requires a regional or multilateral approach to front and back end fuel cycle services and the transition to a global nuclear architecture.

Since the Joint Study conclusions also called for an inter-disciplinary approach and international collaborations wherever possible, as a follow-up, several INPRO collaborative projects were initiated which address the issues identified:

› Global architecture of nuclear energy systems based on thermal and fast reactors including a closed fuel cycle (GAINS);

› Integrated approach for the design of safety grade decay heat removal system for liquid metal cooled reactor (DHR);

› Assessment of advanced and innovative nuclear fuel cycles within large scale nuclear energy systems based on CNFC concept to satisfy principles of sustainability in the 21st century (FINITE); and

› Investigation of technological challenges related to the removal of heat by liquid metal and molten salt coolants from reactor cores operating at high temperatures (COOL).

tem represents a source of energy consistent with a country's sustainable development criteria, if all principles, requirements and criteria are met. If the assessment points to a gap, further R&D studies should be undertaken.

If not all components are met, a given nuclear energy system may still make a significant, interim contribution to meeting the energy needs of a country or region, but will need to change and evolve to become sustainable in the longer term. The results of a NESA can be used to guide this evolution.

An IAEA publication describes how to conduct a NESA using the INPRO methodology: *Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems: INPRO Manual — Overview of the Methodology (TECDOC 1575 Rev.1).*

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by Ray Sollychin

exploring fuel alternatives

Under INPRO, experts are looking at the possibility of using thorium-based fuel cycles to help achieve sustainable nuclear energy in the 21st century.

Thorium, like uranium, is a fertile material that can be used to produce fissile material, which in turn could be used as fuel in a nuclear reactor. The use of thorium to support future large-scale deployment of nuclear energy systems is being explored under INPRO in a Collaborative Project entitled "Further Investigation of Thorium Fuel Cycles". Parties involved in the project include the European Commission, India, Canada, Slovakia, Russian Federation, China, France and the Republic of Korea.

Neutrons from a fission reaction initiated by U235 can also be used to convert through capture fertile material, such as U238 and Th232, to generate new fissile material, Pu239 and U233, respectively. This is important for extending the availability of fissile material which makes nuclear energy sustainable.

The main concern from producing a large quantity of Pu239 is related to proliferation of material since Pu239 can be used to make a nuclear weapon. The same concern exists for proliferation of materials with the use of thorium, since U233 can theoretically be used in a nuclear weapon. However, a small amount of the the fission product U232, whose radioactive decay emits a powerful, highly penetrating gamma ray, makes U233 weapons significantly more difficult to conceal and much more dangerous to handle. Moreover, there are no known U233-based weapons under development in the world today and under the testing moratorium currently in place, a successful development of new weapons technology based on U233 would be difficult to demonstrate or test.

The proliferation-resistance of the thorium fuel cycle could also be improved in future designs of thermal reactors through 'recycling' U233 inside the reactor without removing it from the secured reactor facility for reprocessing.

Using thorium could reduce the production of plutonium and transuranic elements and help with the disposition of military plutonium. In some specific reactor designs using thorium, plutonium can be 'burned', offering a practical and economical method for disposing of nuclear weapon material.

Thorium fuel has better thermal and physical properties as well as irradiation performance than uranium fuel. It could be a better fuel option for nuclear energy system designs that operate at a higher temperature, such as non-electricity applications. Furthermore, the melting point of thorium dioxide is about 500 degrees Celsius higher than that of uranium dioxide. This difference provides an added margin of safety in the event of a temporary power surge or loss of coolant in a reactor.

Another possible advantage of the thorium fuel cycle is related to the long-term management of spent-fuel. A smaller quantity of high-level, spent fuel with fission products that have shorter half-lives is produced by thorium fuel cycles in comparison to the uranium-plutonium fuel cycles. The engineering for the long-term waste disposal in the thorium fuel cycle may be less demanding than the uranium-plutonium fuel cycle, from the point of view of both repository lifetime and space requirements.

The high radioactivity of the thorium spent fuel, mainly due to the presence of the gamma-ray emitting U232 and its decay chains, creates engineering challenges, but not fundamental physics problems, to the designers and operators of spent-fuel management facilities. On the other hand, the presence of strong gamma-ray emitters also provides opportunities for innovative developments of new industrial applications. For example, thorium spent fuel can be incorporated into the design of long-lived fuel (for small and medium sized reactors without onsite refuelling) as an inherent deterrent for sabotage or theft during shipment to a centralized spent fuel processing center. Other applications may be related to the sterilization of medical equipment and use in food irradiation, radiation-therapy equip-

INPRO Thorium Steps

During a IAEA/INPRO consultancy meeting in January 2009 a number of thorium-based fuel cycle options were identified for consideration by Member States of INPRO. In the meeting, the following three groups of fuel cycle options suitable for short-term to mid-term applications were identified:

❶ Once-through uranium/thorium fuel cycle in HWR, PWR, BWR and HTGR. This includes the conventional once-through, fuel shuffling and recycling of mechanical-reconfigured fuel;

❷ Once-through plutonium/thorium fuel cycle in HWR, PWR, BWR and HTGR. This is similar to the first option except existing Pu239, instead of U235, is used to start the fission process prior to sufficient creation of U233 in the reactor core. A special variation of this are designs for the purpose of reducing the plutonium as potential weapon material; and

❸ Synergism between fast reactors (FRs) and thermal reactors, in which a number of FRs are operated as factories for converting Th232 into U233 to feed other reactors.

In addition to the participating members of the collaborative project, several observers from Thorium Power (USA), Thor Energy (Norway) and the Institute of Energy Research at Juelich (Germany) took part in the meeting.

ment, medical diagnostic equipment and custom inspection facility, etc.

Economics of Thorium Fuel

When implemented on a large-scale, the thorium fuel cycle can potentially offer an economic advantage over the current uranium-based open fuel cycle, despite the expectation that the fabrication cost of thorium fuel may be higher than uranium fuel.

The expected possibly higher cost is based on the more difficult handling of U233 and the associated highly radioactive U232. Other factors, however, may mitigate the higher fabrication cost, for example, there is no enrichment required in the thorium fuel cycle, and fewer conversion process steps are required to manufacture natural thorium oxide into fuel forms ready for first irradiation than in the case of uranium.

Further, the 'recycling' capability of thorium fuel and the possibility of higher temperature operation will likely provide some additional economic benefit. The conversion from fertile Th232 to U233 is done during fission, i.e., while energy is generated, and the resulting fissile U233 can continue to undergo fission and produce energy for a long time (higher burn-up), up to the limit imposed by the behavior of the fuel cladding material and supporting structures. Higher temperature operation of future thorium-based reactor designs should increase the nuclear energy systems' thermal efficiency from the current best of 34% to as high as 50% or even higher, directly contributing to a reduction of the fuel cost per unit of energy generation.

Why Can't We Start Using Thorium?

The utilization of thorium could start today, in the current generation of nuclear energy systems with some redesign and relicensing. However, in a once-through fuel cycle (i.e., no recycling to recover the remaining U233 after discharge), the use of thorium fuel is not very economical.

Several advanced designs are being developed to more optimally use thorium with improved utilization efficiency or with specific purposes (for example, plutonium disposition). These include modified designs or evolutionary designs based on current reactor types, such as India's Advanced Heavy Water Reactor and thorium-based VVR-100 jointly developed by the USA and Russia; thorium-based Pebble-Bed Reactor, fast reactors (liquid metal cooled and gas cooled); and advanced designs such as Molten-Salt Reactor and Accelerator Driven System.

In addition, several reactor concepts have been proposed and are currently being developed with the objective of meeting the needs of small energy users. Some of these design concepts can be optimized for the use of thorium fuel.

The biggest challenge facing the introduction of the thorium fuel cycle for commercial power generation is the lack of fuel-fabrication-related infrastructure.

The nuclear industry has benefitted from the availability of similar infrastructure for the uranium fuel, which was made possible by investment in the past for non-civil applications. However, the fuel-fabrication infrastructure for the thorium fuel cycle will have to be developed for commercial considerations.

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by Rejane Spiegelberg-Planer

A Matter of Degree

A revised International Nuclear and Radiological Event Scale (INES) extends its reach.

Any incident taking place in a nuclear facility or involving radiation sources or radioactive substances may give rise to media and public concerns, sometimes resulting in rumors, psychological stress, social tension and even economic consequences. Therefore, timely and accurate responses to media and public concerns are key to avoiding the dissemination of confusing and non-relevant information that often circulates during incidents or emergencies.

Scales are simple way to convey a message. They are used as tools to convey clear and open messages which are also easy to understand and are provided at the right time. Importantly, they provide a solid technical basis to assist us in our judgment.

INES has a sound technical basis and it is a tool for communicating the right message — the safety significance of events and their potential consequences, at the right time.

INES provides for all those aspects: it has a sound technical basis and is a tool for communicating the right message — the safety significance of events and their potential consequences, at the right time.

The Scale

INES was developed in 1990 by international experts convened jointly by the IAEA and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) for communicating the significance of events at nuclear installations. Since then, INES has been expanded to meet the growing need for communicating the safety significance of all events associated with radiation and radioactive material, including transport related events.

In 2008, the IAEA General Conference welcomed the revision of INES, which consolidated previous clarifications and guidance. The General Conference also urged IAEA Member States to designate INES national officers and utilize the scale to put into proper perspective the safety and radiological impact of events in the nuclear and radiation safety area, which was a major step in the worldwide use of a scale.

INES has 7 levels. The upper levels (4-7) are termed "accidents" and the lower levels (1-3) "incidents". Events that have no safety significance are classified "Below scale or Level 0" and are termed "deviations".

It is important to note that events with no relevance to nuclear safety or radiation protection (e.g. a non-radioactive chemical spill, or faults affecting only the availability of a turbine or generator) are termed "out of scale".

A distinct phrase has been attributed to each level of INES in order to express the increasing severity of events from Level 1 to Level 7. These are: anomaly, incident, serious incident, accident with local consequences, accident with wider consequences, serious accident and major accident.

Currently, INES covers a wide range of practices, including radiography, uses of radiation sources in hospitals, operations at nuclear facilities, and transport of radioactive material. By putting events relating to all of these practices into their proper perspective, INES can facilitate a common understanding among the technical community, the media and the public.

The 1986 accident at the Chernobyl nuclear power plant in the USSR (now in Ukraine), is rated at Level 7 on INES — the event had widespread impact on people and the environment. One of the key considerations in developing the criteria for the INES scale rating was to ensure that the significance level of less severe and more localized events were clearly separated from this severe accident. Thus the 1979 accident at the Three Mile Island nuclear power plant is rated at Level 5 on INES, while an event resulting in a single death from radiation is rated at Level 4.

INES is intended to be applicable for all events, the vast majority of which relate to failures in equipment or procedures. Whilst many such events do not result in any actual consequences for individuals, it is recognized that some are of greater safety significance than others. If all such events were rated at Level 0, the scale would be of no value. Thus, it was agreed at its original inception that INES needed to cover not only actual consequences but also potential consequences.

The Revision Process

The revision of INES aimed to incorporate into one document already existing documents which served to clarify specific criteria such as:

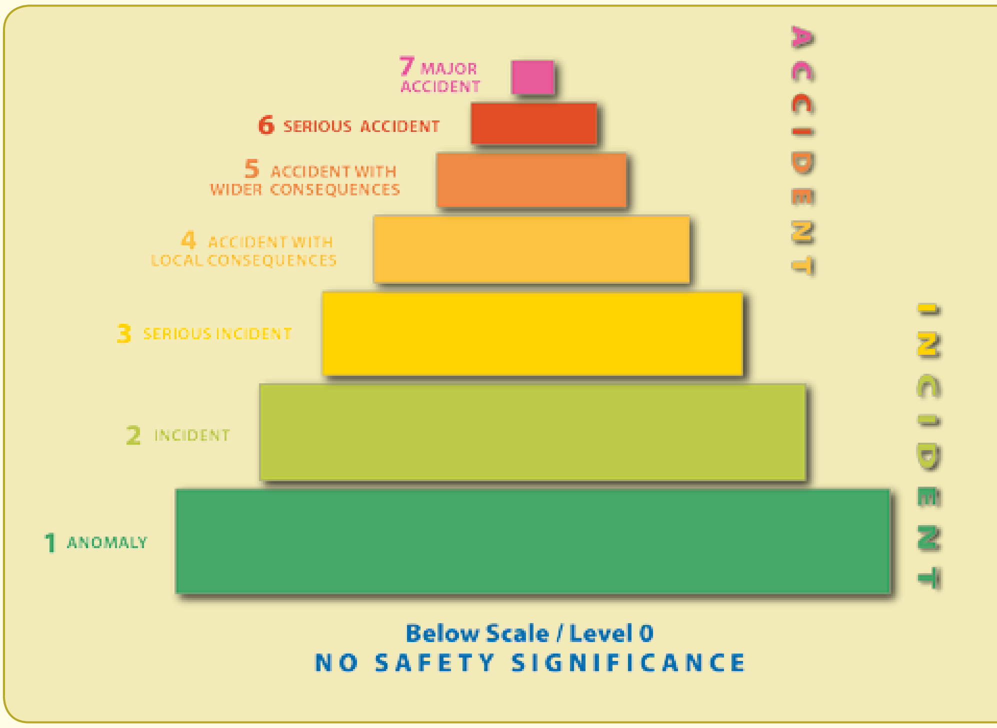
❶ the clarification for fuel damage events at nuclear facilities in use since 2004; and

❷ the additional guidance for rating events related to radiation source and transport in use since 2006.

The revision process also served to incorporate comments received from the INES National Officers and the corrigenda of the 2001 INES Manual on the use of the Scale. To promote the consistent use of the Scale worldwide, it was also found necessary to add examples of rating and adopt appropriate terminology to all applications of the Scale.

The revision was jointly coordinated by the IAEA and the OECD/NEA and involved experts from all related areas: nuclear facilities, radiation safety and transportation. This was essential to bring uniformity and consistent criteria across all applications.

The proposal was reviewed by the 63 INES national officers, who are officially designated by Member States. They were also asked to ensure the involvement of technical experts in each area of application of the Scale. The comments were resolved in meetings with the INES advisory committee and the IAEA and OECD/NEA Secretariats. The committee received and addressed more than 330 comments from 25 countries and the Secretariats. In addition, other international organizations were also invited to major INES meetings. These included the World Association of Nuclear Operators (WANO), European Community, World Nuclear Association and FORATOM.



Scope, Criteria

What are the changes of the new revised INES compared with the 2001 INES Manual? To begin with, it is worth noting that the scope of the scale did not change. Since 2001, INES has been applied to any event taking place at nuclear facilities or during transportation involving radioactive sources. However, the criteria used to rate those events needed better explanations, were no longer applicable or needed to be revised considering up-to-date concepts and techniques.

Ensuring consistent terminology and eliminating ambiguous interpretation was one of the goals of the revision process. Thus, criteria using words such as 'few', 'several', 'of the order of' were explained and examples provided. The meaning of concepts such

To promote the consistent use of INES worldwide, it was also found necessary to add examples of rating and adopt appropriate terminology to all applications of the Scale.

as Below Scale and Out of Scale and the difference between them was also clarified.

Currently, events are considered in terms of their impact on three different areas:

Currently, events are considered in terms of their impact on three different areas:

❶ People and the environment

❷ Radiological barriers and controls at facilities

❸ Defence in depth.

❶ People and the environment

❷ Radiological barriers and controls at facilities

❸ Defence in depth.

The impact on people and the environment can be localized, i.e. radiation doses to one or a few people close to the location of the event, or widespread as in the release of radioactive material from an installation.

Events involving large releases to the environment would be rated at levels 4 to 7 (accidents). Clearly these criteria only apply to practices where there is the potential to disperse a significant quantity of radioactive material. In order to allow for the wide range of radioactive material that could potentially be released, the scale uses the concept of "radiological equivalence". Thus the quantity is defined in terms of terabecquerels of iodine 131, and conversion factors are defined to identify the equivalent level for other isotopes that would result in the same level of effective dose. The criteria for releases were previously referred to as the "off-site" criteria.

For events with a lower level of impact on people and the environment, the rating is based on the doses received and the number of people exposed. Events involving doses to individuals can be rated between level 2 and level 6. However, it is not considered credible for an event involving a radioactive source to achieve level 6. The radiological accident in Goiania in 1987, rated as level 5, is an example of the highest level for such cases.

The impact on radiological barriers and controls at facilities is only relevant to major facilities handling major quantities of radioactive material such as power reactors, reprocessing facilities, large research reactors or large source production facilities.

In those facilities, when a site boundary is clearly defined as part of their licensing, it is possible to have an event where there are significant failures in radiological barriers but no significant consequences for people and the environment (e.g. reactor core melt with radioactive material kept within the containment). It is also possible to have an event at such facilities where there is significant contamination spread or increased radiation but where there are still considerable safety layers (such as redundancy of systems, procedures, etc) remaining that would prevent significant consequences to people and the environment.

In both cases there are no significant consequences to individuals outside the site boundary, but there is an increased likelihood of such consequences to individuals or a major failure in the management of radiological controls.

Those events could be rated from level 3 to 5, the highest on record being damage to the reactor core that occurred in Three Mile Island, in the USA in 1979.

Thus, these criteria cover events such as reactor core melt and the spillage of significant quantities of radioactive material resulting from failures of radiological barriers, thereby threatening the safety of people and the environment. These criteria, together with the criteria for worker doses, were previously referred to as the "on-site" criteria.

Reduction in defence-in-depth principally covers events with no actual consequences, but where the measures put in place to prevent or cope with accidents did not operate as intended.

While many such events do not result in any actual consequences, it is recognized that some are of greater safety significance than others. If these types of events were only rated based on actual consequences, all such events would be rated at Below scale or Level 0 and the scale would be of no real value in putting them into perspective. Thus, it was agreed at its original inception that INES needed to cover not only actual consequences but also the potential consequences of events.

A set of criteria was developed to cover what has become known as "degradation of defence-in-depth". These criteria recognize that all applications involving the transport, storage and use of radioactive material and radiation sources, incorporate a number of safety provisions. The number and reliability of these provisions depends on their design and the magnitude of the hazard. Events may occur where some of these safety provisions fail but others prevent any actual consequences. In order to communicate the significance of such events, criteria are defined which depend on the amount of radioactive material and the severity of the failure of the safety provisions.

Since these events involve only an increased likelihood of an accident, with no actual consequences, the maximum rating for such events is set at Level 3 (i.e. a serious incident). Furthermore this maximum level is only applied to practices where there is the potential, if all safety provisions failed, for a significant accident, i.e. one rated at Levels 5, 6 or 7 on INES. For events associated with practices with a much smaller hazard potential, e.g. transportation of small medical or industrial radioactive sources, the maximum rating on the basis of degradation of defence-in-depth is correspondingly lower.

In summary, INES Level 1 covers only degradation of defence-in-depth. Levels 2 and 3 cover more serious degradations of defence-in-depth, or lower levels of actual consequence to people or facilities. Levels 4 to 7 cover increasing levels of actual consequence to people, the environment or facilities.

Although INES covers a wide range of practices, it is not credible for events associated with some practices to reach the upper levels of the scale. For example, events associated with the transport of sources used in industrial radiography, could never exceed Level 4, even if the source was taken and handled incorrectly. For events involving radiation sources and the transport of radioactive material, only the criteria for people and the environment and for defence-in-depth need to be considered.

The final rating of an event needs to take into account all the relevant criteria described above. Each event should be considered against each of the appropriate criteria and the highest derived rating is the one to be applied to the event.

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Have I Got NEWS for You

The IAEA maintains a system to facilitate international communication of events. This system, namely the NEWS system, is co-sponsored by the OECD/NEA and WANO. It is not a formal reporting system and the system operates on a voluntary basis.

The purpose of NEWS is to facilitate communication and understanding between the technical community (industry and regulators), the media and the public on the safety significance of events that have attracted or are likely to attract international media interest.

Many countries have agreed to participate in the INES and NEWS system because they recognize the importance of open communication of events in a way that clearly explains their significance.

INES member countries are strongly encouraged to communicate internationally (within 24 hours if possible) according to the agreed criteria:

1. Events which are rated at Level 2 and above; and

2. Events which attract international public interest.

It is recognized that there will be occasions when a longer time scale is required to know or estimate the actual consequences of the event. In these circumstances a provisional rating should be given with a final rating provided at a later date.

Events are posted in the NEWS system by the INES national officers, who are officially designated by the Member States. The NEWS system includes event descriptions, ratings on INES, press releases (in the national language and in English), and technical documentation for experts. Event descriptions, ratings and press releases are available to the general public without registration. Access to the technical documentation is limited to nominated and registered experts.

The Big Fix

Global Cleanout to Combat Serbia's Radiological Legacy

by Dana Sacchetti

(Photo: IAEA)

A soft summer rain falls on a decrepit, rusting warehouse in the suburbs of Belgrade, Serbia. From the outside, all appears normal, nothing more than a shabby storehouse set against a small patch of trees. But inside, a pile of decades-old radioactive waste in deplorable condition has sat for decades, posing a threat to the health and safety of people and the environment. More than a thousand sealed radioactive sources remain inside — a half-century's stock of radioactive refuse from the former Yugoslavia and Serbia. But the full picture of what's inside this radioactive storehouse is a mystery, since precise records haven't been kept.

Such is the scene at the Vinča Institute of Nuclear Sciences, a large research campus that served as the nerve center for former Yugoslavia's nuclear research activities since the late 1940s.

Just a few kilometres from the Danube, the site has endured different periods of upheaval and influence, including varying degrees of Cold War-era intervention by the US and the Soviet Union. In 1959, the USSR supplied Vinča with the nuclear fuel and technical assistance to construct Vinča's 'RA' reactor, a 6.5 megawatt, heavy-water moderated research reactor capable of using fuel highly enriched in U235. The RA reactor was actually the second to operate at Vinča, and was preceded by the country's first nuclear reactor, a heavy-water zero-power critical assembly (which is still in operation). There has been much speculation as to the original intentions for the facility under Yugoslavia's then-leader Josip Broz Tito, and some research seems to indicate that a modicum of weapons research may have been conducted at Vinča in its early days.

Changes in government, the breakup of Yugoslavia, and the NATO bombing campaign in 1999 are all factors that conspired to keep Vinča's management, direction, and focus in a constant state of flux. These dynamics brought Vinča to where it is today; and serve as a prime example of capable scientists and sophisticated equipment falling prey to political winds of change.

Concerns about Vinča on the part of the international community grew in the mid-1990s, when IAEA teams were dispatched upon Serbian request to inspect the site. These visits were instrumental in alerting the outside world about the state of the nuclear fuel on site, and the inherent risk to health and safety of those around Vinča.

As part of the IAEA and global community's push to support reduced enrichment for research and test reactors, along with concerted efforts to return highly enriched uranium (HEU) fuel to the country of origin, an extraordinary level of international cooperation has coalesced to clean up Vinča.

The first major step in the Vinča project took place earlier this decade, when the most urgent threat to proliferation was dealt with. In 2002, an international operation to return 48 kilograms of unirradiated HEU fuel of Soviet-origin came about after protracted negotiations between then-Yugoslavia, the US, Russia, the IAEA, and other parties. The transport of the fuel was conducted amid intense security, with over 1200 armed guards ushering a convoy of trucks to the Belgrade airport for a flight to Russia, where the HEU would then be down-blended to a low-enriched form. IAEA safeguards inspectors watched over the procedure by gauging the fissile material, inspecting records, and applying seals to the shipping containers.

The Current Workload

Since return of the unirradiated HEU, the foremost priority has been to deal with two and a half tons of Russian-origin irradiated, spent nuclear fuel elements, which were initially used in the RA reactor. As the reactor last went critical in 1984, the SNF has been stored for decades in aluminium barrels in an adjoining spent fuel pool. However, the pool's water chemistry has been poorly maintained, leading to corrosion of the fuel element's aluminium cladding and leakage of fission products into the storage pool, though not into the environment. The water's condition is further degraded by an accumulation of sludge, increasing the pool's turbidity and lending it an inky black colour.

So the push is now on to repackage and repatriates the spent fuel for return to Russia, and the strong support and involvement of the Serbian Government has been instrumental in moving this project forward. An agreement between Serbia and Russia that governs the transfer of the fuel was signed this past June, and work is set to begin in autumn. Yet the task is fraught with complexities, and long lists of preparatory steps need to be taken to facilitate the fuel repacking and removal work.

The Vinča Institute of Nuclear Sciences is the site of an aging research reactor initially built with cooperation from the USSR in the 1950s. The site has fallen out on hard times in recent years, however, there are radioactive dangers in need of urgent attention.
(Photo: IAEA)

IAEA Director General Mohamed ElBaradei visited the facility in early July 2009, to assess the progress at Vinča. "The unused nuclear waste is in poor condition and needs to be moved as soon as possible. The situation is under control for now, but it could be very dangerous from a safety and security point of view," he commented.

To remove, characterize, and repackage Vinča's spent fuel, technologically unique operations will have to be performed. Sludge in the pool needs to be removed, custom fuel handling equipment needs to be designed and fabricated, and enhanced radioactivity monitoring systems need to be installed before repackaging begins. The fuel also needs to be stabilized and undergo thorough analysis before it can be removed. Finally, roads leading to the spent fuel storage room need to be reinforced to increase loading capacity and access for the trucks, cranes, and steel casks that will be used in the operation. Over 50 experts and technicians have been assigned for the task ahead. A target date of the end of 2010 has been set for the shipment, and work is set to begin in autumn 2009 to begin the fuel repackaging portion of the project.

"For the Vinča project, we've needed access to huge, expensive technologies to move this massive amount of fuel back to Russia," said John Kelly, the IAEA Special Programme Manager tasked with coordinating the Agency's work.

Two hangars chock-full of more than 1000 disused radioactive sealed sources and other radioactive waste have sat for decades in degraded condition. The sealed sources and waste need to be removed from the two aging hangars and conditioned for secure and safe storage in new long-term storage facilities.
(Photo: IAEA)

Radioactive Waste

Yet another important dimension to the Vinča clean-up effort that the IAEA and the international community are helping Serbia with is the construction of new facilities to deal with the legacy of radioactive waste at Vinča. Two hangars chock-full of more than 1000 disused radioactive sealed sources and other radioactive waste have sat for decades in degraded condition. The sealed sources and waste need to be removed from the two aging hangars and conditioned for secure and safe storage in new long-term storage facilities.

All told, the waste will be dealt with by a waste storage facility, a secure storage bunker, and a waste processing facility. These three systems are in various stages of development, but the IAEA has committed to working with Vinča and Serbian regulators to commission these new installations. A sealed source conditioning facility is also on the near horizon. The support to the radioactive waste management improvements includes safety and security assistance, training and experts, facility upgrades, regulatory assistance, and equipment donations. Much like the spent fuel repatriation, the radwaste management project is expected to take several years to complete.

The Importance of Success

Logistically and financially speaking, the Vinča Institute Nuclear Decommissioning (VIND) project is the largest Technical Cooperation programme in the Agency's history. Several divisions within the IAEA have deployed technical officers to work on the project, which involves the Departments of Safety and Security, Nuclear Energy, Safeguards, Legal Affairs, Procurement Services and Technical Cooperation. The funding aspect has been particularly challenging and given the complexity of the operation, it is little wonder that the price tag is expected to be $47.5 million for the full spent fuel repackaging and repatriation portion. The VIND programme in total is projected to reach roughly $75 million. To date, Serbia, the EU, the Czech Republic, Russia, Slovenia, Italy, UK, USA and the Nuclear Threat Initiative (a non-government donor) have made contributions to the project. The IAEA has also provided support through deployment of equipment, experts, and other assistance.

"With the vast amount of funding needed for the VIND project, pulling together such a disparate donor pool has been nothing short of miraculous," explained Kelly. "But momentum has been the key driver in making progress towards donations — when donors see you actually making progress, then they want to participate. Donors want to invest in success."

VIND highlights the IAEA's unique role and importance in collaborating with and coaxing financial assistance from a diverse donor pool.

"We're working closely with the Serbian government and our goals are identical," said ElBaradei. "We must ensure that there are no similar risks either here in Vinča or elsewhere in Serbia."

Though undoubtedly an expensive venture, the work is necessary, as leaving the site in its current condition is not an option. The VIND project is a prime example of the international community coming together through the IAEA to solve an important and complex safety and security challenge.

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Development of a Continent

by Mickel Edwerd

For 20 years, an intergovernmental agreement supported by the IAEA has contributed to foster nuclear science and technology for African development.

The African Regional Cooperative Agreement (AFRA) is an intergovernmental agreement established in 1990 by the IAEA and African Member States to further strengthen and enlarge the contribution of nuclear science and technology to socioeconomic development on the African continent.

AFRA seeks to maximize the use of the available infrastructure and expertise in Africa and assists countries to move toward regional self-sufficiency using peaceful applications of nuclear techniques. Based on the social context and the economic goals of its Member States, AFRA works to deepen the commitment of Member States to the application of nuclear science and technology for their socioeconomic development through sustained funding.

The AFRA Agreement is renewed by its Member States every five years for a term of five years. This renewal is achieved by notifying the Director General of the IAEA of the AFRA Member States acceptance of the extension the Agreement, and of their desire to continue participating in the Agreement. The current third extension will remain in force until 3 April 2010.

The IAEA is not party to AFRA, but provides technical and scientific backstopping as well as financial and administrative support, in accordance with the rules and procedures governing the provision of technical assistance to its Member States.

Mandate and Management

AFRA supports regional self sufficiency in the peaceful application of nuclear techniques by establishing and strengthening necessary infrastructure, coordinating intellectual and physical resources and cost efficient dissemination of innovative methods and practices.

Following the decision made by the High Level Policy Review Seminar (HLPRS) in Aswan, Egypt, in November 2007, to support the improvement of the managerial procedures of AFRA, increase its effectiveness and promote full ownership of its programmes, the new management structure of AFRA includes three Committees — namely the Programme Management Committee, the Partnership Building and Resource Mobilization Committee and the High Level Steering Committee on Human Resource Development and Nuclear Knowledge Management.

> **AFRA seeks to maximize the use of the available infrastructure and expertise in Africa and assists countries to move toward regional self-sufficiency using peaceful applications of nuclear techniques.**

A Regional Strategic Cooperative Framework

The AFRA Regional Strategic Cooperative Framework (RCF) is the principal planning tool for setting regional cooperation priorities and developing AFRA regional cooperative programmes.

This framework, adopted by AFRA Member States in November 2007, covers the period 2008–2013. The RCF constitutes the frame of reference for the formulation of AFRA regional programmes and is used as the main modality for strengthening the planning and programming of AFRA regional projects, which covers six thematic areas. These are human health; food and agriculture; water resources; sustainable energy development; industrial applications; radiation and waste safety and nuclear security.

♦ Human Health: AFRA interventions focus on areas where nuclear techniques have proven to make a difference such as cancer, malnutrition and communicable diseases;

The development of drought tolerant lines has also been of great importance to the AFRA Member States. As a result, six new crop varieties have been released and several countries have promised mutant materials and are in the advanced stages of development.

♦ Food and Agriculture: AFRA fosters regional cooperation in the use of nuclear techniques in the fields of animal production, crop production, soil fertility and water management, insect and pest control and food safety;

♦ Water Resources: AFRA focuses its interventions in projects that aim to maximize the regional technical capabilities in the water sector, including the establishment of regional centres in isotope hydrology and the promotion of investigations related to integrated water resources assessment, groundwater dependent ecosystem protection (wetlands) and the management of shared aquifers in Africa;

♦ Sustainable energy development: AFRA promotes the dissemination and wider use of the IAEA's analytical tools (MAED, MESSAGE and FINPLAN) for energy planning. The regional effort will provide strong linkages across the region with respect to planning and strategizing energy options, including the investigation of the feasibility of nuclear power as a source for electricity production and seawater desalination;

♦ Industrial applications: AFRA cooperative activities focus on the promotion of radiation processing technologies, the use of radioisotopes for troubleshooting, the development of non-destructive testing techniques for industrial quality control and the effective use of research reactors; and

♦ Radiation and waste safety, and nuclear security: the AFRA strategy in this field promotes Member State self assessment of their regulatory infrastructure, radiation protection services, emergency preparedness and response capacities and nuclear security. AFRA also promotes the establishment of centralized national radioactive waste management facilities in Member States to manage waste in the safest and most secure manner.

AFRA Success Stories

Human Health: Under AFRA, 40 radiotherapy centres in 18 African countries have been upgraded and more than 250 radiotherapists, medical physicists, nurses and radiographers have been trained on improved radiotherapy protocols, medical physics and management of radiotherapy departments.

AFRA also supports efforts to strengthen regional capabilities in clinical nuclear medicine. The programme has enhanced Member State capabilities in the diagnosis and treatment of coronary artery disease, refractory arthritis, thyroid diseases, liver cancer, metastasis bone pain and lymphoma. Sound medical physics practices with regard to nuclear medicine have been promoted.

Food and Agriculture: A total of 17 AFRA Member States are working on the improvement of 'neglected crops' or traditional crops that have not yet benefited from conventional breeding techniques. The development of drought tolerant lines has also been of great importance to the AFRA Member States. As a result, six new crop varieties have been released and several countries have promised mutant materials and are in the advanced stages of development.

Other achievements include the development of fully established tissue culture laboratories in almost all the participating countries as well molecular laboratories in three countries.

AFRA Members. As of June 2009, the AFRA enjoys a membership of 34 African countries: Algeria • Angola • Benin • Botswana • Burkina Faso • Cameroon • Chad • Democratic Republic of Congo • Central African Republic • Côte d'Ivoire • Egypt • Eritrea • Ethiopia

Industrial Applications and Quality Management: The programme has provided training to managers and decision makers, facilitated regional networking and promoted the certification of nuclear laboratories in several countries. This network has already held its second regional conference on quality management in AFRA countries, aimed at improving recognition and implementation of ISO standards and their benefits for international trade and communication in Africa.

Information and Communication Technologies (ICTs): AFRA Member States have established sustainable national and regional capabilities in the use of ICTs for training and education in the fields of nuclear science and technology relating to agriculture, human health, environmental monitoring, water resource management, nuclear instrumentation and other related nuclear fields. Emphasis was placed on training nuclear engineers, computer scientists and technicians, which was supplemented by the provision of ICT telecentres to several countries.

Radioactive Waste Safety: AFRA developed, in collaboration with the South Africa Atomic Energy Corporation (Necsa), the Borehole Disposal for Sealed Radioactive Sources system, which was designed to provide safe, secure, permanent and economic disposal of disused sealed radioactive sources.

Nuclear Security: The AFRA programme has provided nuclear security training for more than 850 participants, including law enforcement, customs, civil defense and regulatory personnel. Regional workshops on illicit trafficking information management and coordination have fostered communication, good practices and working relationships among stakeholders in AFRA Member States.

Regional Self Reliance and Sustainability

AFRA Member States promote regional self-reliance and sustainability in the peaceful, safe and secure application of nuclear science and technology through the principle of technical cooperation among developing countries (TCDCs).

AFRA Member States implemented a regional strategy in human resource development (HRD) and nuclear knowledge management (NKM) through the AFRA Network for Education in Nuclear Science and Technology (AFRA-NEST) and a high level steering committee on HRD and NKM has been formed to oversee these initiatives. A harmonized curriculum for the AFRA Masters Degree in Nuclear Science and Technology has been adopted as a minimum standard for awarding such a degree in the region.

The AFRA programme also supports the establishment of International Nuclear Information System (INIS) centres for new AFRA Member States, as well as enhancing existing national facilities to access reliable, trustworthy nuclear information resources to support national and regional nuclear activities and programmes, to preserve national nuclear literature and to exchange expertise and share resources in the field of nuclear information processing.

Regional Designated Centres

A process to recognize Regional Designated Centres (RDCs) at the professional level and in higher education has been initiated to cater to the needs of Member States that do not yet have the capacity to present equivalent curriculum. In the context of AFRA, RDCs are defined as an established African institution able to provide multinational services. AFRA Member States apply a rigorous process to recognize RDCs.

As of June 2009, 11 institutions have been recognized by the AFRA Member States as Regional Designated Centres in various fields of activity. The IAEA is supporting a high priority project for the period 2009–2013 to enable students to attend RDCs through fellowship programmes.

The Human Factor

AFRA also uses specialized teams composed of regional experts to perform a range of services, including conditioning and storage of sealed radio-

• Gabon • Ghana • Kenya • Libya • Madagascar • Mali • Mauritania • Mauritius • Morocco • Namibia • Niger • Nigeria • Senegal • Sierra Leone • South Africa • Sudan • Tunisia • Uganda • Tanzania • Zambia • Zimbabwe.

20 Years Young

In collaboration with the Government of Cameroon and the International Atomic Energy Agency (IAEA), the African Regional Cooperative Arrangement (AFRA) on Research, Development and Training related to Nuclear Science and Technology organized its 20th Technical Working Group Meeting (TWGM) in Yaoundé, Cameroon in July 2009. This meeting marked the celebration by of AFRA's 20th anniversary with an exhibition highlighting achievements and success stories under its programmes. A press conference focused on AFRA achievements, policies and future challenges, was also held.

The meeting brought together National Coordinators from the 34 AFRA Member States to deliberate on AFRA policy and programme related matters. Participants reviewed the AFRA draft Annual Report for 2008 and reviewed the implementation of cooperative projects, and also formulated recommendations for consideration by the AFRA Meeting of Representatives. Other issues addressed during the meeting included: the establishment of the AFRA Programme Management Committee (PMC) and the AFRA-Partnership Building and Resource Mobilization Committee (PBRMC); the initiation of the AFRA Fund; fundraising; the implementation of the AFRA Regional Cooperative Strategic Framework 2008-2013; and the linkages between Country Programme Frameworks and other national planning documents such as national development plans, UNDAF, PRSPs including the review of AFRA operational matters.

active sources, auditing of radiotherapy and nuclear medicine facilities, and advising on steps to achieve self-reliance and sustainability of national nuclear institutions.

When appropriate, AFRA Member States appoint Project Scientific Consultants (PSCs) to provide, upon request, technical backstopping to AFRA Member States and to the AFRA committees. PSCs are African scientists recognized as experts and regional leaders in their respective fields. PSCs participate in AFRA activities in their individual capacity. As of June 2009, 15 African scientists have been recognized by the AFRA Member States as PSCs of AFRA projects related to several thematic fields.

AFRA provides advice on the formulation and implementation of realistic Strategic Action Plans (SAPs) to guide national nuclear institutions to enhance their sustainability and to remain functional and relevant, with an agreed level of dependence on government support and the capability to adapt to changes in the external environment.

Challenges

One of the major challenges facing AFRA is the wide variation of development within AFRA Member States in the field of nuclear science and technology. This is a challenge that needs to be monitored constantly to avoid gap widening as the number of Member States increases. Another challenge for the near future will be maintaining the programme's expansion at the level desired by Member States taking into consideration the scarcity of resources. To face this challenge, an AFRA Fund has been established to enable Member States' voluntary contributions to attain 25% of the unfunded portion of the AFRA programme.

The synergy and innovative dynamics generated by AFRA should ultimately lead to the creation of a regional market of goods, services and knowledge in the field of nuclear science and technology. This has already started under some AFRA projects where several goods are being provided from within the region. This initiative will represent a significant challenge for AFRA as it is expected to play a leading role in understanding the evolution and trends of the regional demand for nuclear applications as well as promote the development process of goods and services and establish the legal framework by harmonizing regulations and procedures and facilitating transactions. Future emphasis will therefore be placed on small and medium sized joint ventures and cooperative undertakings between African countries themselves as well as between them and Member States in other regions.

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Researching Success

by Marta Ferrari

An IAEA survey offers an interesting insight in the status of nuclear research institutes in Central and Eastern Europe.

Over the last few years, the role of the nuclear research and development institutes (RDIs) has changed profoundly. From being privileged and strategic research institutions with one customer, i.e., the government, they have become just one of many research institutions competing for attention and funding. Several nuclear RDIs are struggling to find their place in this world, with erosions of funding and status that has made it difficult to attract and retain talented staff. On the other hand, there are institutes that overcame a deep financial crisis and managed to complete the transition with great success.

Although there is a widespread feeling within the nuclear community that some nuclear RDIs are in financial distress, there are no current statistical data. A 1989 IAEA report and a 1996 OECD report reviewed the mission and status of nuclear RDIs but neither of them provided an analysis of the financial situation. To fill the gap and provide information about trends in the nuclear sector and the impact of Science & Technology (S&T) policy on nuclear RDIs in 2004, the IAEA initiated a Technical Cooperation Project to support Central and Eastern European RDIs working in nuclear power and non-power applications. Twenty-five research institutes from fifteen countries participated in a comprehensive survey and provided information on their financial status, revenue sources and trends, human resources, and their facilities for the period between 2001 and 2006. The institutes were also asked to supply data on selected performance indicators (including number of patents applied for and obtained, and number of publications in respected journals), legislation, policy and management.

The challenges have been particularly severe in the Central and Eastern European region, where structural political and economic changes affected the way science is funded and managed. Some nuclear RDIs have seen a sharp decline in funds and status, the loss of some of their most talented scientists, which jeopardises their long-term viability, and, in some cases, poses significant safety and security concerns. Findings from this survey may provide interesting insights in the situation of nuclear RDIs in other regions as well.

Global Trends in Science and Technology

The Science and Technology (S&T) sector is faced today with complex and diverse challenges. National science budgets are under pressure, and many countries are changing how Research and Development (R&D) is funded, reducing direct subsidies and introducing competition for both governmental and alternative sources of revenue.

On the other hand, the transition toward knowledge-based economies is creating new opportunities in the S&T sector as governments look to it to foster economic growth through innovation. A number of countries in Central and Eastern Europe have recently joined the European Union (EU) which defined the Lisbon Strategy to create a "knowledge triangle" of research, education and innovation to underpin the European economic and social model, as well as economic growth. This strategy seeks to increase investment in science and technology across the EU to a target of 3% of GDP by 2010, with two-thirds of funds coming from the private sector. By comparison, funding for R&D in most Central and Eastern European countries is only around 1% GDP, of which about 90% is provided by the governments.

Research Reactor WWR-K, Institute of Nuclear Physics, Almaty, Republic of Kazakhstan.
(Photo: NNC, Kazakhstan)

R&D has become more international, reflecting a more interdependent and globalized world. Governments still maintain national networks, but increasingly emphasize international cooperation, to avoid duplication of expensive infrastructure and because scientific excellence requires an exchange of ideas and cooperation that crosses borders.

These challenges and opportunities directly impact RDIs, including nuclear RDIs. It is important for these institutions to take these trends into account as part of their vision and strategy.

Millionaires or Nobel Prize Winners?

Most RDIs develop their strategy and their internal management depending whether the mission is more oriented to basic research, applied research, services or production. Many of them are active across several areas, while a few attempt to cover the full continuum of activities. The distinction is helpful to understand how effective internal organization and policies are in fulfilling an institute's mission and strategy. A 'Nobel Prize Winner 'institute has an academic focus, wishes to create an environment for excellence in research and rewards mainly publications. A 'Millionaire' institute is focused on linkages to commercial markets, considers financial success a primary institute goal and rewards staff for revenue generation and commercial projects.

A 'Nobel Prize Winner ' institute has an academic focus, wishes to create an environment for excellence...while a 'Millionaire' institute is focused on linkages to commercial markets.
(Photos: Photodisc)

One of the major challenges facing nuclear RDIs is maintaining the balance between the institute's mission as perceived by its stakeholders, its strategy as defined by the institute management and the policies on such issues as staff incentives and control of intellectual property rights. Inconsistencies between mission, strategy and policy create obstacles to sustainability and success, because they impede revenue development and demotivate staff. A work environment that rewards creativity needed for basic science applications is not well suited to the repetitive, efficient production of radioisotopes, for example.

While there are RDIs with refined management systems, in general, their internal management is unsophisticated. Only one-third of the surveyed RDIs have either a business plan or a similar strategic document. Systems for staff incentives are not well developed, and in several cases do not align staff rewards with the institute's objectives. Examples include institutes engaged in service or production activities that exclusively reward their staff on the basis of academic reputation and publications. In some cases, these policies are set at a national level and are outside of the institutes' control, highlighting the need for dialogue between the institute management and their government policy-makers.

Are nuclear RDIs in financial distress?

Significant changes have occurred in Central and Eastern Europe over the past two decades, including accession to the EU by some countries and rapid GDP growth. Overall, RDIs increased their revenues in line with the positive domestic economic climate, though this is not universally true. Some RDIs have been less successful, with revenues declining over the period.

Reliance on government funding varies significantly, ranging from near zero to almost the entire budget. Historically, government funds have been provided in the form of a direct subsidy, but there is an increasing emphasis on funding R&D through competitive grants. Many institutes are actively developing revenues from other sources, but for the majority of them, governments remain their most important sponsors and clients.

In many cases, researchers doubt that "new" revenues will benefit their RDI, as they expect the government to reduce its funding as other revenues are developed. This perception forms a powerful internal barrier to development of alternative sources of funds, to the point that RDIs are more likely to develop non-governmental funding sources if it is clear that government funds will not be reduced as a consequence.

Knowledge based societies need their RDIs to be an engine of GDP growth by creating and developing intellectual property and stimulating innovation. However, this role is not uniformly recognized in the RDI funding systems, which often do little to reward RDIs for commercialising technology or making expertise available through consultancy and services. RDI internal management systems address this strategic role only weakly, with less than half of the RDIs having a policy for the protection and management of intellectual property, and almost none earning revenues from intellectual property rights.

Reporting and Funding Relationships

The survey showed that funding and reporting relationships have become disconnected in a number of cases, making it difficult for RDIs to meet the objectives of the funding organization and thus setting the stage for chronic funding deficits. Just over half of the surveyed RDIs are strongly related to the bodies (Ministry of Science or equivalent, and the Academy of Sciences) that determine their country's S&T policies. Examples of conflicting relationships include RDIs that are controlled by the Academy of Sciences but funded by the Ministry of Economy to provide support services. Resolution of these types of conflicts will enable RDIs to better contribute to the countries S&T needs.

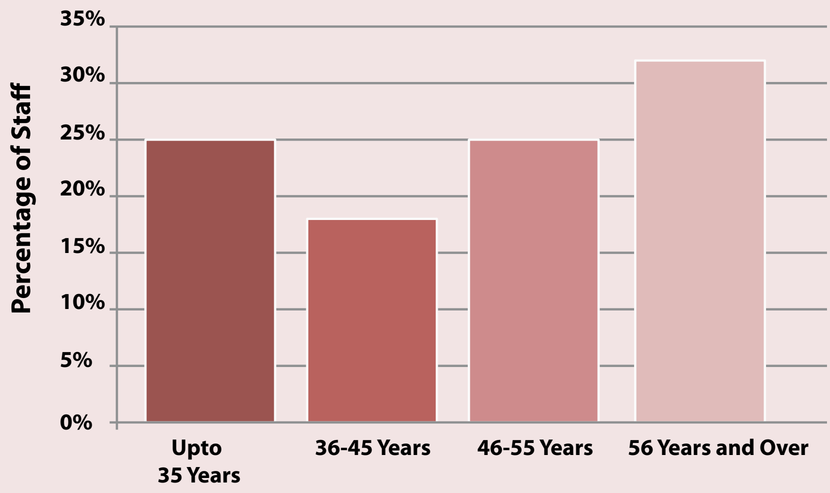
The Human Resources Challenge: the age gap

Staff age distribution showed that there is a major challenge in the institutes' future. Several RDIs have a deficit of experienced staff in the 36 to 55 age group and are facing problems with knowledge retention as the oldest members of staff retires. In aggregate, there is a deficit of scientific staff in the 36 to 45 age group, reflecting difficulties in attracting and retaining talented staff experienced over the last 10-20 years, but suggesting an increasing ability to attract new graduates.

Key success factors

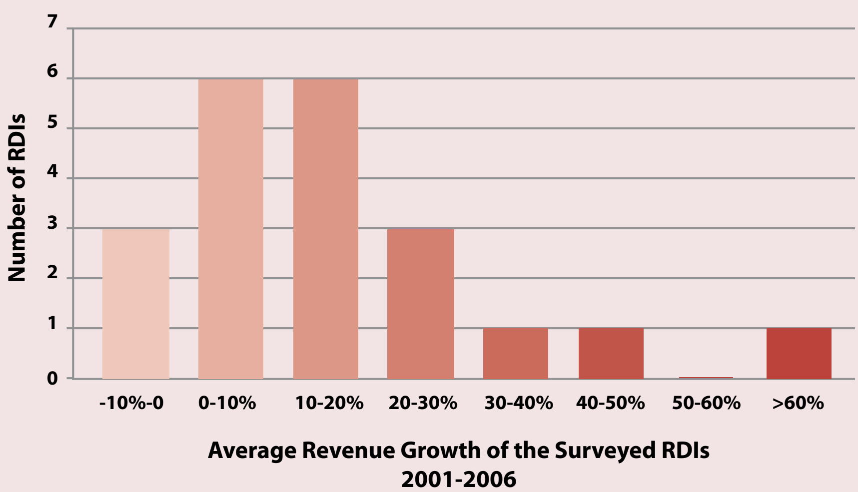
There are several possible models for successful RDIs, and the key success factors for nuclear RDIs are similar to those for institutes in other scientific disciplines. A crucial key to success is for RDIs to align

Age Distribution of RDIs' Staff Members



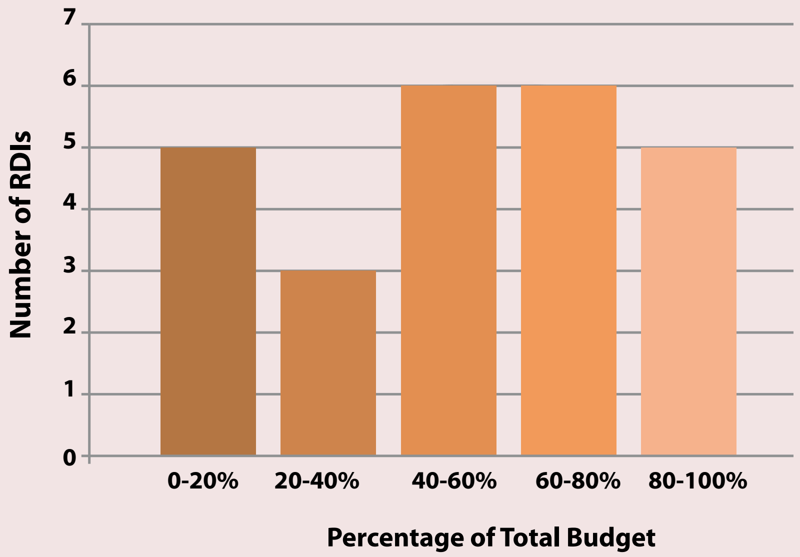
source: IAEA

RDIs' Revenue Growth



source: IAEA

RDIs' Government Funding
as percentage of total budget



source: IAEA

themselves, their policies and their strategies to their capacities, their environment and the needs of their stakeholders.

RDIs exist within the environment created by their governments' regulations and policies, which can either help or hinder the institutes in their quest for sustainability. Thus, RDIs need to proactively manage their environment and nurture relationships with the government and other stakeholders.

The S&T environment is increasingly international, so it is also essential that the RDIs develop peer group networks to supplement their capabilities to provide international visibility and standing, and ensure access to major international programmes. RDI managers interviewed for the survey stressed that even though participation to international programmes such as the EU Framework Programmes does not provide a major source of funding (rarely rapresenting more than 5-10% of the institutes budget), it is essential to foster the institute reputation and eventually important to gain national funding.

RDIs that participate in commercial markets with either products or services, have a particular need for effective accounting systems and accounting policies that can realistically calculate costs and so make possible meaningful profitability assessments. They should also develop a purposeful business development function to build the customer base and business revenues. To succeed, these RDIs need to retain some of the revenues gained in the commercial sector and have flexibility in staff recruitment and retention policies so that they can meet the demands coming from the marketplace.

The Way Forward: Challenges and Opportunities

RDIs face significant challenges to respond to the changes in S&T priorities and in the structure of R&D funding. This requires new approaches as well as application of new skills.

Yet, there are also many opportunities. The renaissance of nuclear electricity generation is creating a new demand for the skills, experience and capabilities of RDIs. This includes training of professional staff, material investigations, development of the science and supporting technologies for new reactor systems. Outside nuclear energy, there are new opportunities in many fields. For example, expertise in nuclear physics and nuclear technologies can be combined with that from other scientific disciplines to address problems in agriculture, industry and medicine. The commitment of the European governments to substantially increase national R&D funding levels envisages also new opportunities for RDIs.

There is not just one possible model for RDIs: there are several, all successful in their own way. The main key to success is to have high quality RDIs that align themselves, their internal policies, and their strategies to their capacities, the environment and the needs of their country. Successful RDIs have demonstrated the importance of institutional policies concerning key strategic elements such as incentives for staff, intellectual property ownership, and sound financial management. Particularly crucial is the establishment of the right incentives in term of human resource policies, the ability to mobilize and motivate research staff in line with the institute's mission and the stakeholders' objectives.

Whatever the specific model, it is crucial that institutes take a proactive stance to shape their environment and determine their future.

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This article summarizes the findings of the IAEA report Nuclear Research and Development Institutes in Central and Eastern Europe, June 2009.

Toxic Playpens

by Sasha Henriques

Pollution from lead and other heavy metals are agents of disease for many of the world's children. In Jamaica and other poor countries, the health risks associated with this kind of pollution are all too often seen as the inevitable price of economic development.

When a baby is born, mothers see the promise of infinite possibilities. But for Carol Allen, the promise turned to tears. Her first three children grew up devastated by the effects of lead poisoning caused by environmental contamination in Red Pond, on the Caribbean island of Jamaica.

In 1963 a privately owned battery supply company built a lead recovery plant in semi-rural Red Pond, 40km from the capital Kingston.

A community with hundreds of families sprang up around the factory as people came from surrounding areas looking for work. Twenty years later there were more than 2,000 residents.

Carol says, "Sometimes when they began smelting at the factory, the black cloud would cover every house in the community until you couldn't see."

Carol had three children in Red Pond. Her eldest, Gary, is now 22. When he was a boy he would play hide-and-seek in the factory yard. He's been having seizures since he was 17. And even with medication, he still has two seizures every month. Lately, his mother says, his jaw becomes dislocated every time he has a fit. The seizures are so frequent that he can't hold down a proper job.

Carol's second eldest, Nicola, is 20 this year. Nicola has seizures too. She hasn't spoken since she was three, and can no longer walk. She can't feed herself and can't control her bladder or bowel functions. She requires round-the-clock care from her mother.

Carol's second son Jovian would have been 16 this year. But he had a seizure when he was 12 on his way home from school one day. He fell into a gully by the roadside and drowned before help could arrive. "Many many children died because of lead poisoning in Red Pond. They were born with lead and died." says Carol.

During the lead recovery plant's 26 years of operation, people in the area and in other poor communities began operating their own backyard smelters.

"Progress gave us this problem," says Dr. Gerald Lalor, Director General of the International Centre for Environmental and Nuclear Sciences (ICENS) in Jamaica, whose work is supported by the IAEA and funded by the Environmental Foundation of Jamaica, the Jamaican Government, the Inter-American Development Bank, the CHASE Foundation and the University of the West Indies.

"When people realized that batteries could be recycled for profit, and how easy it was, they said 'I can do this too'," says Lalor.

Backyard smelting contaminated play areas and other places throughout the community. Children who ate the dirt, sucked their fingers, or played outside absorbed large amounts of the heavy metal.

The youngest suffer the most. "Exposure in the first two years of life plays hell with children's brains," says Lalor. Lead is a metal with no known biological benefit to humans. A direct link has been found between early exposure and extreme learning disability, hyperactivity, violence and lethargy. Too much lead in the body interferes with the normal

Nicola (centre) and Gary (right) are victims of lead poisoning, and still suffer serious health effects from exposure as young children. Their mother Carol (left) says many children have died from lead poisoning.
(Photo: S.Henriques/IAEA)

Sherene Thompson (left) and her children Shane (centre) and Sasha-Gaye (right). The Thompson yard was once used for smelting lead from used car batteries. Today it's no longer a health hazard after the contaminated soil was covered.
(Photo: S.Henriques/IAEA)

development of the brain, the central nervous system, the kidney and the heart.

Tip of a Lead Iceberg

Jamaica's lead exposure problems represent the tip of an iceberg, experts say. Worldwide, lead exposure is a major health hazard. The Blacksmith Institute, an environmental health group in the United States, ranks lead recycling from batteries among the world's top 10 pollution problems.

An estimated 120 million people worldwide are exposed to lead in the environment — in air, soil, water. Dangerous lead contamination is found in children in some 80 countries. In 2008, eighteen children died from lead poisoning in Dakar, Senegal.

The Blacksmith Institute estimates that over 12 million people are affected by lead contamination from processing of used lead acid batteries throughout the developing world. Battery recycling occurs in almost every city in the developing world, and even in some countries undergoing rapid transition.

The problem of unsafe unregulated recycling is exacerbated by high unemployment among the underprivileged, growing industrialisation, increasing wealth in the middle classes, which results in increased car ownership, and therefore more batteries being imported.

People are exposed to lead through informal and formal—but poorly regulated—smelting activities. Informal smelting involves breaking the batteries with an axe and disposing of the sulphuric acid. Often the battery acid, which contains some lead, is carelessly dumped on the ground, waste pile or into the nearest water body. Then the lead plates are removed from the plastic battery casing. The plates are boiled in a large metal container and impurities are siphoned off with a ladle.

World-wide, informal battery melting is done to recover and sell lead to larger processers. And despite the risks, overriding economic needs drive people to continue.

In Jamaica, some battery smelters have also resisted efforts to change their behaviour.

Head of ICENS' nuclear labs and Chief Reactor Operator, Charles Grant, says "It's purely economic; because you're explaining to them that they're doing things that are harming their children, or in one case we saw, their grandchildren. And in the other breath he'll tell you, 'That's how I make my money. This is how I put food on the table.' For them it's sometimes a case of having their children die now from starvation or die later from lead poisoning."

Retarded Development

Sasha-Gaye and Shane Thompson live in Maverly, a rundown community on the outskirts of Jamaica's bustling capital city, Kingston. When she was two years old Sasha-Gaye was admitted to the Bustamante Hospital for Children after vomiting non-stop. Three weeks later came the seizures. Then, doctors unravelled the mystery - Sasha-Gaye was poisoned by lead from a backyard smelter operated by her father.

Sasha-Gaye's mother Sherene was perplexed by the illness. "The doctors gave her medication and sent her home. But she was still having behaviour problems, acting as if she was retarded. She would just do stuff and you didn't understand why she was doing it."

During an ICENS survey of the area, the case came to researchers' attention. "That's how Sasha-Gaye started getting treatment and stopped having the problems," says Sherene.

Lead poisoning is determined by measuring the ratio of lead to blood in the human body. When Sasha-Gaye was first admitted to hospital in 1998 her blood lead level (BLL) was 130 micro grams per decilitre of blood (µg/dL), thirteen times the accepted limit, which is 10 µg/dL.

Treatment involves introducing a substance, often calcium disodium EDTA, into the body that essentially latches onto the lead in the blood. From there, the now soluble metal is passed out in urine and faeces. This process is called chelation. With regular treatment, the child's condition can improve significantly, granted there is no re-exposure to the lead source.

But five years after she was first admitted to hospital, Sasha-Gaye was back, along with Shane, her 2-year-old brother. Sasha-Gaye's BLL was 62 μg/kg, and Shane's was 135 μg/dL. Three years later in 2006, both children's readings were no better than in 2003.

"You take the lead out of the blood and the child recovers to a large extent and people used to think it was cured," says Lalor. "But we are finding several examples where two years later the blood lead is high again and the child just keeps turning up ill at hospital. That's either because the parents have not told us the truth that they have stopped working with batteries, or because the lead is leaking out of their bones and going back into their blood."

Lalor and his team have been on the environmental trail of lead and other heavy metals for more than a decade. The IAEA provides advanced testing equipment and training for these scientists.

"Monetarily our role is small," says Rick Kastens, Head of one of the two Latin America Sections in the IAEA Department of Technical Cooperation. "But the impact has been significant. It means that children like Sasha-Gaye can get treated much quicker if they are exposed to lead. Doctors know test results in a matter of hours rather than weeks because of the equipment and training we've provided."

The IAEA has provided a total reflection x-ray fluorescence unit and germanium photon detectors which are used to test for the presence of heavy metals like lead in humans and the environment.

No Quick Fix

The threat posed by lead pollution is not fully captured by its death toll or the number of those who are hospitalised. Grant says, "Lead poisoning doesn't allow children to reach their full potential as adults."

Yvonne Turner is the Principal of a preschool in a squatter settlement called Mona Commons, where lead smelting was widespread. She says her teachers noticed hyperactivity and learning difficulties in pupils who were later found to be suffering from lead poisoning.

"About four years ago my teachers and I had been noticing problems with the students who came from that area. But we didn't know what the problem was. Some of them had great difficulty learning, especially two children who lived very near to the main smelting area. You would tell them something now, and in the next few minutes they would forget what you said. When ICENS tested our students, they found that the blood lead levels of those two were higher than all the rest," says Turner.

A Problem to Remediate

More needs to be done by government and other agencies worldwide to eliminate the threat lead poses to vulnerable populations, in the view of experts at the IAEA and in the field.

"First of all, lead needs to be taken seriously. There need to be properly enforced environmental controls for factories and mines, comprehensive remediation plans for sites that are already contaminated, as well as ongoing and thorough public education," says Kastens.

Blacksmith Institute advocates that implementing the necessary interventions first require the international community to take on the responsibility of identifying all polluted places where human health is at risk, and provide resources to support the remediation of these sites because even a small smelter can contaminate a significant area. And as the market for reclaiming secondary lead grows, many developing countries have entered the business of buying used batteries in bulk in order to recycle them.

Unlike some other contaminants, lead never disappears on its own. "If it's in the blood it has to be medically removed. And if it's in the soil, the dirt has to either be dug up and dumped in a safe place or you have to concrete the entire polluted area," says Lalor.

Such basic and practical intervention is often prohibitively expensive for the very poor.

♦ ♦ ♦

In Jamaica, ICENS has been spearheading remediation of contaminated sites for the last five years. But the scientists describe it as an uphill task that requires the full force of state machinery behind it.

The communities of Hope Flats and Kintyre sprang up on the site of an old abandoned lead mine, and the local preschool was unknowingly built on top of pure mine waste. All 60 students at the school were found to be lead poisoned in 2004. Lalor says, "In certain areas like the Kintyre Basic School we simply pour concrete over sidewalks and play areas to con-

The IAEA's Role

Over the last 20 years, the IAEA has operated 32 projects in 51 countries dealing with various aspects of heavy metal pollution and the effects on humans and the environment. There are now eight projects ongoing in 25 countries.

In Kenya and seven other African countries for example, the Agency is training scientists to better use nuclear techniques to assess contamination of the marine environment around the continent.

And in Argentina, the IAEA is involved in conservation and management of natural resources by finding the source of methyl-mercury and identifying the main bio-accumulation pathways in significant lakes of Nahuel Huapi National Park.

The Agency contributes to the study of elements such as arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, tin, titanium and zinc in a variety of ways. For some Member States the IAEA provides testing equipment and training for scientists. For others, the Agency's reference materials are basic tools in quality control when new soil, plant and water samples are tested.

Testing for lead and other heavy metals in the environment and in the human body involves using the complementary techniques of neutron activation analysis (NAA), anodic stripping voltametry (ASV) and total reflection x-ray fluorescence (TXRF). The assay methods are used to determine the heavy metal composition of soils, food, water, body tissue and blood.

With NAA the material to be studied is exposed to neutrons in the core of the reactor. This causes nuclear transformations of elements in the sample, followed by radioactive decay. Each element forms radioactive nuclides which emit radiation of characteristic energy, like a "gamma fingerprint". In this way many elements, including heavy metals, can be identified and measured in the sample at the same time.

For XRF, instead of using neutrons to excite the elements in the sample, X-rays are used. Each element then de-excites by the emission of a characteristic X-ray. However, unlike NAA the samples do not remain radioactive after the process is complete.

In Jamaica, the IAEA provided a TXRF unit which is used for XRF analysis, as well as high-purity germanium photon detectors (a.k.a. gamma ray detectors) which detect the different "gamma fingerprints" being emitted by the samples under analysis.

tain the contaminating source (dirt) and protect those who interact with this environment."

But some scientists say they're being forced to become social workers, a role they're ill-equipped to handle. "In Kintyre the migration rate due to violence is just far too high. So by the time you educate persons on lead exposure, they've moved away and you have to educate another set," says researcher Kameaka Duncan.

"We really need the government to stand up and pay attention to the research that has been done because when our funding runs out there will still be children who need consistent medical attention and nutritional support," she says.

Hope Flats and Kintyre were built on top of pure toxic waste. "You can probably see why the political directorate would not want to touch it," says Blossom Anglin-Brown, Head of the University of the West Indies Health Centre, "where are they going to relocate the people to? And that's really what needs to be done."

Finding a Durable Solution

State governments aren't the only ones challenged by the prospect of handling environmental pollution problems. Only a fraction of international aid is set aside for remediation of critically polluted sites, despite the significant threat posed to human health, and despite the proven effectiveness of such intervention.

But there are steps being taken by private sector entities and international non-governmental organisations.

In Jamaica for instance, the Caribbean Recycling Company will next year begin collecting used lead acid batteries for export to Israel where both the plastic and the lead will be recycled. Co-owner Geoffrey Ziadie anticipates that 100 tonnes of batteries will be exported each month when operations begin.

Internationally, the Blacksmith Institute is working in seven countries to mitigate against lead pollution from improper recycling through education and remediation of legacy contaminated soils. The project also involves developing responsible policies for managing these batteries, and either formalizing used battery collection or providing other sources of income for the informal operators.

There are also plans for a $400 million fund dedicated to combating toxic pollution in developing countries that has resulted from industrial, mining, and military operations.

Despite increases in international aid however, the havoc wreaked by heavy metal pollution on vulnerable populations will persist in developing countries unless poverty and alternate sources of employment are addressed.

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To hear podcast and view the photoessay of this article, visit www.iaea.org

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1960	Chile, Colombia, Ghana, Senegal
1961	Lebanon, Mali, Democratic Republic of the Congo
1962	Liberia, Saudi Arabia
1963	Algeria, Bolivia, Côte d'Ivoire, Libyan Arab Jamahiriya, Syrian Arab Republic, Uruguay
1964	Cameroon, Gabon, Kuwait, Nigeria
1965	Costa Rica, Cyprus, Jamaica, Kenya, Madagascar
1966	Jordan, Panama
1967	Sierra Leone, Singapore, Uganda
1968	Liechtenstein
1969	Malaysia, Niger, Zambia
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1972	Bangladesh
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1986	Zimbabwe
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1995	Bosnia and Herzegovina
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1997	Latvia, Malta, Republic of Moldova
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1999	Angola
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2001	Azerbaijan, Central African Republic
2002	Eritrea, Botswana
2003	Honduras, Seychelles, Kyrgyz Republic
2004	Islamic Republic of Mauritania, *Togo*
2005	Chad
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Year denotes year of membership. Names of States are not necessarily their historical designations. For States in italic, membership has been approved by the IAEA General Conference and will take effect once the necessary legal instruments are deposited.

Note:

♦ *The Democratic People's Republic of Korea (DPRK), which joined the IAEA in 1974, withdrew its membership on 13 June 1994.*

♦ *Cambodia, which joined the IAEA in 1958, withdrew its membership on 26 March 2003.*

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