from High to Low

by Pablo Adelfang and Ira Goldman

The IAEA is helping to reduce the use of high-risk nuclear fuel at the world's research reactors.

Research reactors play a key role in the development of peaceful uses of atomic energy. They are used for the production of isotopes for medicine and industry, for research in physics, biology and materials science, and for scientific education and training. They also continue to play an important role in support of nuclear power programmes.

The IAEA's data shows there are 249 operational research reactors worldwide. Of these, more than 100 reactors are still fuelled with highly enriched uranium (HEU). It is considered high-risk nuclear material since it can be easily used for a nuclear explosive device.

As part of a developing international norm to minimize and eventually eliminate HEU in civilian nuclear applications, research reactor operators increasingly are working with national and international agencies. They are being encouraged and supported to improve their physical security arrangements, convert their reactors to low-enriched uranium (LEU) fuel, and ship irradiated fuel back to the country of origin.

Reducing Use of Highly Enriched Uranium

For more than twenty years the IAEA has been supporting international efforts associated with reducing the amount of HEU in international commerce. Projects and activities have directly supported a programme the United States initiated in 1978, called Reduced Enrichment for Research and Test Reactors (RERTR). The IAEA's work additionally supports efforts to return research reactor fuel to the country where it was originally enriched—so-called "take back" activities.

IAEA initiatives have included the development and maintenance of several databases with information related to research reactors and research reactor spent fuel inventories. These databases have been essential in planning and managing both RERTR and take-back programmes. Other Agency activities through technical cooperation and other channels have supported the conversion of research reactors to using lower enriched fuels.

In other ways, the IAEA supports the exchange of information among experts. It co-sponsors annual RERTR international meetings (in late October 2006, South Africa hosts this gathering). In cooperation with Norway, the Agency also organized the June 2006 "International Symposium on Minimization of Highly Enriched Uranium in the Civilian Nuclear Sector." Consensus at the meeting indicated that LEU can be used for almost all applications in which HEU is currently used.

IAEA support of RERTR and the take-back programmes was strengthened in 2004, following the establishment in the United States of the Global Threat Reduction Initiative (GTRI) and ensuing recommendations of the RERTR meeting. The common goal is to reduce both proliferation and security risks by eliminating or consolidating inventories of high-risk material.

This article outlines a few of the areas where the IAEA is concentrating its efforts.

Technical Support & Assistance

The Agency's regular programme activities are focused on establishing the technical foundation for HEU minimization. This specifically includes supporting research reactor fuel conversion to LEU, radioisotope production from

LEU, and providing overall programmatic support for fresh and spent fuel shipments from research reactors.

Additionally, national and international efforts are supported to develop, qualify, and license LEU research reactor fuel. A guidebook is being developed for use in negotiations of fuel supply and to support fuel development activities. Fuel element manufacturers and national laboratories have developed fuel types suitable for LEU utilization in most of the world's research reactors.

In recent years, requests for IAEA assistance for research reactor conversion have increased considerably. In some cases, such as in Chile, technical assistance was provided for the fabrication and qualification of domestically produced LEU fuel. In other cases, as with the TRIGA research reactor in Romania, the IAEA procured commercially produced LEU fuel assemblies to complete the conversion. In Portugal, the IAEA is supporting the purchase of a full LEU core for the conversion of a research reactor, and in Poland, is procuring LEU fuel for conversion of the Maria reactor.

In Libya, technical assistance supported quality-control inspections of the fuel acquired under a trilateral arrangement with the USA and Russia for the conversion of the Tajoura critical assembly and research reactor. The Agency is providing a pool-side monitoring and visual inspection system, and training and technical assistance for its use.

Bulgaria, Kazakhstan, Ukraine, and Uzbekistan also have requested assistance under national technical cooperation projects regarding LEU core conversions. And a national project with Jamaica will be initiated for full-core conversion of its SLOWPOKE reactor, which will receive technical and financial assistance from Canada and the USA.

While many research reactors still need to be converted to LEU fuel, the IAEA is already looking ahead and considering an expanded scope for future conversion efforts. A meeting in February 2006 of representatives from both government and non-governmental organizations prepared an updated list of operating facilities using HEU. Also examined were other facilities that use HEU, such as critical assemblies, pulsed reactors, and civil propulsion reactors. Follow-up meetings are planned.

Production of Medical Radioisotopes

An element known as molybdenum-99 (Mo-99), whose decay product is technecium-99m, is the most widely used medical radioisotope in the world. It accounts for over 20 million diagnostic tests yearly. The vast majority of Mo-99 is produced by four major commercial firms using HEU targets. However, in recent years, Argentina and Australia have been able to demonstrate the technical feasibility of producing Mo-99 from LEU.

The IAEA is involved in various initiatives to minimize the reliance on highly enriched uranium and encourage the "take back" of spent fuel to the country of origin.

In 2005, the IAEA started a coordinated research project involving ten countries. The aim is to develop techniques for small-scale, indigenous production of Mo-99 using LEU or neutron activation. Institutions in Chile, Kazakhstan, Libya, Pakistan and Romania are receiving technical advice and assistance from Argentina, India, Indonesia, the Republic of Korea, and the USA.

Russian "Take-Back" Activities

The Russian Research Reactor Fuel Return (RRRFR) programme focuses on the recovery of irradiated research reactor fuel originally supplied by Russia to facilities outside the country. It evolved from IAEA efforts. In 2000, Director General Mohamed ElBaradei wrote to fifteen countries possessing such material, inquiring as to their interest in returning such material to Russia. A series of "Tripartite Initiative" meetings were organized that helped facilitate conclusion of a USA-Russia bilateral agreement in May 2004.

The main vehicle for assisting countries in this "take-back" initiative is an IAEA technical cooperation project called "Repatriation, Management and Disposition of Fresh and/

or Spent Nuclear Fuel from Research Reactors". The objective is support the return to Russia of fresh or irradiated HEU and LEU fuel.

A grant from the US-based non-governmental organization Nuclear Threat Initiative (NTI) has enabled the IAEA to play an important role in planning for the "take-back" of Russian research reactor spent fuel. The IAEA is organizing and carrying out, with US and Russian experts, fact-finding missions to research reactor sites in 12 countries. This grant continues to support technical and project management activities related to supporting the RRRFR as a whole. It includes developing workshops, training, and guidance documents, and developing and implementing resource mobilization activities for the programme.

In August 2002, the IAEA cooperated with the US, Russia, Serbia and NTI for the removal of 48 kg of fresh HEU from the Vinca Institute to the Russian Federation. NTI provided $5 million to three IAEA technical cooperation projects in Serbia. This was part of an agreement with the governments of the USA, Russian Federation, and Serbia.

The IAEA projects aim to safely remove 2.5 metric tonnes of irradiated HEU and LEU fuel from Serbia and transport it to the Mayak Reprocessing Plant in the Russian Federation; to improve radioactive waste management facilities at Vinca (including building a secure storage facility for high-activity sources); and to plan for the decommissioning of the Vinca research reactor.

The spent fuel project has achieved important progress in 2006. The IAEA is in final negotiations with a contractor to repackage and transport the spent HEU and LEU fuel at Vinca. In addition to funding from NTI, the US Department of Energy has committed to provide resources to package, transport, and reprocess the HEU spent fuel, and the European Union appears likely to also commit significant resources to the project. This would result in available resources of approximately $15 million, with about another $10 million needed to complete the project by 2009. (Also see box, "The Clock is Ticking" on page 20.)

Fresh and Spent Fuel Shipments

The IAEA carries out studies related to planning fresh and spent fuel shipments. They include examining transport cask options, assessment of transport routes, and providing advice for handling deteriorated research reactor fuel.

Since September 2003, with extrabudgetary funding from the US Department of Energy (DOE), the IAEA has contracted for transportation services for seven shipments of fresh HEU from six countries (Bulgaria, Czech Republic, Latvia, Libya, Romania, and Uzbekistan). The result has been the removal of about 120 kilograms of fresh HEU.

In a mission completed in August 2006, the IAEA helped Polish authorities remove approximately 40kg of highly enriched uranium from a nuclear research reactor near Warsaw.

Another five to six shipments are being planned for the second half of 2006.

In addition, the IAEA is procuring ten high-capacity transport and storage casks at a value of 4 million Euro (contributed by DOE). Available by December 2006, these will initially be used for shipment of spent fuel from the Nuclear Research Institute, Rez, in the Czech Republic. Thereafter, they will be available on a lease-free basis for other irradiated research reactor fuel shipments under the Russian take-back programme.

Contributing to Global Goals

The IAEA contributes significantly to international efforts serving the goal of reducing the use of high-risk nuclear fuel. Programmes for the minimization of HEU involve countries around the world that are home to research reactors.

Through Agency-supported channels, they are receiving technical support and assistance in key areas. The work involves partnerships with governments and non-governmental organizations, and experts with a wide range of experience in the field. Considerable progress has been made, and the cooperative foundation has been set for further advances in the years ahead.

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the Clock is ticking

To Secure Serbia's Bomb-Grade Waste

On the outskirts of Serbia's capital Belgrade, nuclear weapons-grade waste sits in a pool of murky water. It is potential material to make dirty bombs: lots of them. An IAEA inspector team is at the Vinca facility, a shut-down research reactor at the Institute of Nuclear Sciences, to check that none of it is missing.

Small in size, the fuel elements fit into the palm of your hand. Each a radioactive cocktail of plutonium and high-enriched uranium (HEU) waste. "The biggest threat is, of course, the terrorists," says Vinca's former operations manager Obrad Sotic, who worries about levels of security on site. It would be very difficult for a terrorist to make a nuclear bomb out of them, experts like Sotic say. But explode a single fuel element with dynamite in a crude "dirty bomb" and it's radioactive aerosol becomes a weapon of terror.

"For terrorists ready to commit suicide it won't be a problem to steal a lot of these fuel elements, which are very light and easy to be taken, and use it as a dirty bomb," Mr. Sotic said.

Two IAEA inspectors lift covers over the pool to inspect the spent fuel. It simmers in stagnant water where it has been cooling for the past three decades. The room is roughly the size of a 25 metre swimming pool yet contains more than half of the HEU fuel that the Soviet Union ever produced to fuel research reactors outside of the Russian Federation.

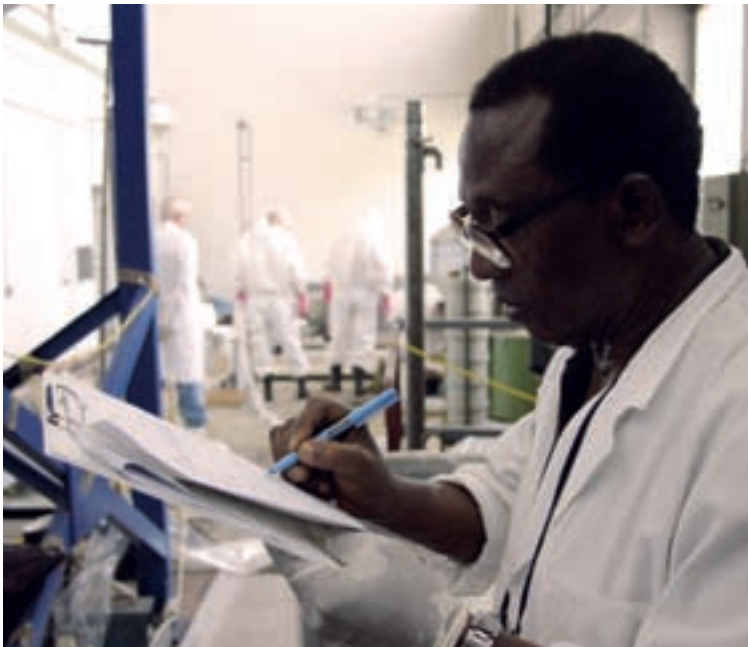
It's not only terrorist risks that are driving IAEA and Serb concerns about Vinca. The fuel elements are corroding and leaching radiation into the water. "After a long time in such conditions, the fuel starts leaking and the fission products, which are highly radioactive, spread out and of course endanger this room and the people working here. And, if it goes higher and higher it will endanger the surroundings," Dr. Sotic warns.

The sound of Geiger counters crackle and beep, as the IAEA inspectors go about their job. Fears are the contamination will seep into the water table or escape via the ventilation system.

Now is the time to remove this fuel and begin decommissioning before the fuel and facility degrade further. —Mike Durst

A village of 4,000 residents sits at the doorstep of the site. Dobrila Markovic owns a local shop five minutes drive away. "I'm not worried about it," says the mother of three. "But during the war, I was scared that the facility might be bombed and spread radiation."

The bomb-grade waste remained secure throughout major upheavals: the Balkan wars, the break-up of both Yugoslavia



and the USSR. But in today's climate with fears of nuclear terrorism rife, it poses a magnet for would-be nuclear thieves while it remains in such conditions at Vinca.

Mike Durst is the IAEA's point man tasked to clean up the site. "The fuel is clearly both an environmental and a proliferation issue. Therefore in order to prevent an environmental hazard from occurring and to prevent, of course, the material from getting into the wrong hands, we need to get rid of it. And now is the window of time."

It is a complex, costly operation. The price tag is well in excess of $10 million and funds are short. Plans are afoot to ship the nuclear fuel back to Russia, which supplied it during Soviet times to power a nuclear research reactor at Vinca. The reactor was shut down 22 years ago.

With IAEA support, almost 50 kilograms of unused HEU fuel was removed from the reactor on 23 August 2002 in a night-time operation that sealed off half of Serbia and involved 1,200 armed troops. The HEU — enough to make two simple nuclear bombs — was airlifted to Dimitrovgrad in Russia for reprocessing. Now the remaining spent fuel also needs to be sent to Russia, Durst and others say.

Logistically, it is a far more difficult operation. "It's almost like comparing a light bulb to the sun: it is much, much more complicated," Mr. Durst said. "This fuel is highly radioactive, it's leaking, so everything will have to be done remotely." The fuel must be removed from its current containers using special tools that have to be designed to operate remotely. Once it is repackaged, it will be put into heavily shielded shipping containers that are specifically licensed for international transport.

"We're going to ship across several international boundaries — and the whole operation is going to take time, expertise and money," Mr. Durst said.

A donor's conference is planned for September 2006 at the IAEA's Vienna headquarters to help raise awareness and the needed funds. Contributions from the Nuclear Threat Initiative ($5 million), the United States ($4 million) and the Agency's Technical Cooperation programme ($1.5 million) are a first step to making the removal operation a reality.

Until Vinca is stripped of its spent fuel, it will remain a tempting terrorist target. "We need to close the financial gap to remove the fuel," Serbian Science Minister Aleksandar Popovic said. "We need to ensure Vinca is safe from a possible terrorist attack and environmental danger," he said.

The IAEA is working closely with the Serbians to upgrade security and protective measures on-site. From installing centrally monitored alarms and new ventilation systems, to constructing secure storage areas. "Without the help of the Agency, we wouldn't make it," Minister Popovic said.

The top priority is to get rid of the spent fuel. For Obrad Sotic that day can not come soon enough. "Day by day it becomes more and more dangerous. And that's the main reason we have to ship this fuel as soon as possible."

—Kirstie Hansen, IAEA Staff Reporter

Photos: Top—The fuel elements look similar to this but are dangerously radioactive. Each is a cocktail of plutonium and high enriched uranium wastes. Explode just one with dynamite as a crude bomb and its radioactive aerosol can kill and contaminate. Left—IAEA Inspectors during an inspection of the spent fuel. Photos: IAEA