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Cleaning Up Vinča: Completion of an Eight-Year Project to Secure Serbia's Spent Fuel

In late December last year, more than 8 000 highly radioactive nuclear fuel elements arrived at a secure Russian facility as part of an IAEA-coordinated effort to repatriate all the spent fuel from a Serbian nuclear research reactor.

Decades after the Soviet Union built and fuelled the research reactor at the Vinča Institute of Nuclear Sciences, the condition of the fuel had deteriorated, spurring a coalition of international partners to repackage the fuel elements and ship them back to Russia. Vinča´s first shipment of highly enriched uranium (HEU) fresh fuel was returned in 2002, and the December 2010 delivery of spent fuel was the last of the reactor´s inventory.

"This was a very complicated project. We had to involve governments, contractors, and non-governmental organizations," said IAEA Director General Yukiya Amano. "It was a success story and we are very happy to continue to cooperate with stakeholders to repatriate highly enriched uranium."

Figure 1: Containers loaded on rail wagon in Serbia.

Beyond Design Basis

I would like to start my remarks by offering my sincere condolences to the people of Japan over the devastating natural disaster.

Losses of so many human lives, so many homes, entire villages is beyond comprehension.

At the time of writing this, the situation at the Fukushima Daiichi nuclear power plant remains very serious. As we know, there is serious damage to reactors, spent fuel, radioactive waste infrastructure and spread contamination caused by flood water, explosions, and debris. However, most importantly, no-one has lost life due to this accident.

I'm convinced that we all recognize the courage of the emergency response teams who have been battling the situation under extremely difficult circumstances. When the IAEA's Director General, Mr Amano visited Japan, his main message was: "You are not alone." He said that Japan could count on the full support of the international community - both practical and moral - in overcoming it.

The IAEA, in our Incident and Emergency Center, in our offices by various expert support teams, in our teams in Japan, we are working at full stretch, together with other countries and international organizations, to help Japan bring the crisis to an end.

At this stage, the priority remains stabilizing the nuclear reactors and fuel in reactor hall pools, and restoring safety. The 5th Review Meeting of the Contracting Parties to the Convention on Nuclear Safety provided a first formal opportunity to consider lessons learned. Lessons will need to be learned and the IAEA is where that discussion should take place, when the time is right. The IAEA intends to hold a high level meeting 20 – 24.6.2011 in order to make an initial assessment of the Fukushima accident, its impacts and consequences; consider the lessons that need to be learned; launch the process of strengthening nuclear safety; and strengthening the response to nuclear accidents and emergencies.

Lots of aftermath work will also fall in the competence of you, dear fuel cycle and waste technology colleagues; namely dealing with damaged spent fuel, revisiting severe fuel pool accident issues like design basis, fuel pool technologies, fuel failures due to mechanical reasons, zirconium cladding oxidization and zirconium-fires and their prevention and mitigation; dealing with highly radioactive liquids and other waste, contaminated structures and debris; remediation of the site and large contaminated areas outside the site, as well as decommissioning issues.

I have also much good news to share with you. The main topic of this Newsletter is the substantial result of so far the largest project we have had in the IAEA, namely the completion of Vinča-project.

Two-and-a-half tonnes of highly radioactive nuclear spent fuel arrived at a secure Russian facility after a multinational project performed by Serbia and coordinated by IAEA. The material was removed from a Serbian nuclear research reactor where it posed potential security and environmental threats. This was the largest single shipment of spent nuclear fuel made under an international programme to repatriate such material to the nations that originally supplied it.

This Newsletter focuses also on other research reactor issues. Despite their small size, these reactors play a very important role, as you can see from our news articles.

Tero Varjoranta, Director (T.Varjoranta@iaea.org)

Repatriation Missions

The IAEA has, over the years, participated in a variety of repatriation missions in partnership with the US-led Global Threat Reduction Initiative (GTRI) to return HEU fuel to its country of origin and to convert research reactors to use low enriched uranium fuel.

The United States of America and the former Soviet Union were the primary exporters of reactor fuel that was enriched to near nuclear weapon-grade levels, and some facilities with HEU fuel do not have adequate security to protect the fuel. Some also suffer from poor maintenance, leading to a growing risk of an environmental accident.

As for Soviet-origin reactor fuel, "we´ve shipped fuel from different places in Europe, such as Hungary, Romania, Poland and the Czech Republic," said IAEA Special Programme Manager John Kelly. "It´s been shipped back from the Libyan Arab Jamahiriya, shipped back from Vietnam, a little sprinkling from all over the world."

Similarly, the USA welcomes back US-origin spent nuclear fuel, including a batch this year from Turkey.

"With the removal of all remaining highly enriched uranium from Serbia, we are one step closer to achieving US President Barack Obama´s goal of securing vulnerable nuclear material around the world," said Thomas D´Agostino, Administrator of the US National Nuclear Security Administration (NNSA).

"The elimination of this material reduces the risk that it could be stolen by terrorists and highlights Serbia´s commitment to global nuclear non-proliferation efforts."

The IAEA has played different roles in these missions, sometimes coordinating the entire project as it did with the Vinča material, at other times simply by applying IAEA safeguards to verify the successful transfer.

Vinča Project

The amount of fuel at Vinča was unusually large, and some of it contained 80-per cent enriched uranium, approaching the purity needed for nuclear weapons. The urgency of the situation heightened after the 2001 terrorist attacks in the USA, so US officials and the Nuclear Threat Initiative (NTI) agreed to fund the removal of fresh HEU fuel from Vinča in 2002. NTI, a Washington, D.C.-based non-governmental organization committed to reducing the spectre of nuclear risks, said it hoped its financial contribution would kickstart fuel removal efforts at Vinča and elsewhere.

"At the time, the US government came to us needing outside funding, and we responded very rapidly," said NTI Chief Executive Officer Sam Nunn.

"They asked us for US$5 million and within 24 hours, we had committed that US$5 million."

That seed money triggered contributions from a variety of governments, turning the Vinča project into the IAEA´s largest technical cooperation endeavour ever, involving about US $55 million in total. Most of the project´s technical assistance to Serbia was overseen by the Department of Nuclear Energy’s Research Reactor Section and the Department of Nuclear Safety. Project management was provided by the Technical Cooperation Department and the Office of Nuclear Security. Additionally, the NNSA contributed to the project, as did Slovenian, Hungarian, Romanian and Czech nuclear authorities and companies. On the Serbian side, the project was coordinated through the Public Company Nuclear Facilities of Serbia (PC NFS), which was created by the Serbian government in 2009 to be the entity responsible for the safe removal of spent nuclear fuel from Vinča.

Serbian officials have expressed their satisfaction and pride in the project´s success, which serves as a model for other nations.

"We can say that we are happy and we can say that we are a little bit proud that we succeeded in answering all the questions, facing up to all the challenges and successfully finishing the job," said Radojica Pesic, Director General of the PC NFS.

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Insight to the Fuel Repatriation Project from Vinč Institute

A conversation with Pablo Adelfang, Head of the IAEA´s Research Reactor Section:

What type of reactor is housed at Vinca? What type of fuel did it use and who supplied that fuel?

The research reactor at the Vinca Institute of Nuclear Sciences was a 6.5 MW heavy water reactor. It was a Soviet designed and supplied reactor. The fuel was also supplied by the Soviet Union, and was 80% highly enriched uranium (HEU), although the reactor used 2% enriched uranium as well. The reactor and fuel were not of a very common design.

What type of activities were carried out in the Vinča reactor? How many years did it operate, and when was it shut down?

The reactor first went critical in 1959 and was shut down in 1984. While it was operational, it was used to carry out physics experiments, dosimetry work, some material irradiation, and radioisotope production.

What happened to the nuclear fuel when the reactor was shut down?

The spent fuel was stored at the reactor site in a spent fuel pond. However, by the mid-1990s, it was clear that this was not a viable long-term storage solution. On one fact-finding mission, the IAEA discovered that there was no water purification system in the pool, so the spent fuel elements were deteriorating and losing integrity. With repeated measurements, we saw the radioactive contents of the pool water rising. There were concerns that the fuel assemblies would lose all integrity and further complicate clean-up efforts. There was also some leftover fresh (unirradiated) fuel on site; one of our first actions in 2002 was to ship these fresh fuel elements back to Russia.

Why did Serbia decide to repatriate the fuel? What role did the IAEA play in their decision process?

The Institute had three problems with the deteriorating fuel. First, it had a problem with long-term storage of spent fuel, because the facility wasn´t set up to store fuel for long periods of time. Second, an environmental problem was brewing, as the fuel assemblies continued to corrode and contaminate the pool, although there was no evidence of a leak or release to the environment. And third, there was a nuclear security problem, because there was HEU in the spent fuel pool. So this combination of issues led Serbia to turn to the IAEA for assistance in repatriating the fuel to Russia.

Since Serbia was a fairly new IAEA Member State in 2002 (having recently become independent of the former Yugoslavia), it lacked many political and legal resources, such as a Nuclear Regulatory Authority, that are needed to run such a large project. It also lacked the physical infrastructure and finances to carry it out. So the IAEA was involved in every phase of this project, from assisting with legal and financial planning and coordinating donor support, to getting contracts signed and advising on spent fuel repackaging and shipment.

What steps were taken to start the project? How did it progress from there?

In 2002, all of the fresh nuclear fuel (material that had not yet been in the reactor, and so was not irradiated) was shipped back to Russia. This shipment was actually the first repatriation of fresh fuel to Russia under the present programme, and it helped lay groundwork for an entire programme of fuel repatriation to Russia.

After that, intense planning began for repackaging the corroded spent fuel elements. We carried out several studies of the fuel and the surrounding fuel pond. The fuel was stored in two types of containers: aluminium barrels, and fuel channel holders. Both had been stored in water of poor quality in the pool for years.

We knew that re-packing the fuel would be difficult, because it needed to be done underwater to protect operators from being irradiated and to avoid dispersion of radioactivity during the process. So we knew that we needed to bring in a lot of purpose-designed equipment to help out with the repacking. We also knew we´d need large numbers of transport casks for the fuel.

Our next goal was finding the money to take on such a big project. The Nuclear Threat Initiative (NTI) paid for the shipment of fresh fuel back to Russia, and gave additional funds to start implementing the spent fuel project. Funds were also given by the US Department of Energy´s National Nuclear Security Administration. In the end, the European Union, the Serbian government, the Czech Republic, and other donors also contributed - everyone chipped in to make this international project happen.

We received bids from several companies to lead the project; the IAEA helped Serbia analyze these bids and select the best option. Ultimately, a consortium of Russian companies was selected to carry out the work, and in 2006, a tripartite contract between the IAEA, the Vinča Institute, and Sosny-Mayak-Tenex was signed.

Before the contract was signed, the IAEA had helped to draw up the regulations that Serbian nuclear authorities would use and to carry out studies to determine the condition of the fuel assemblies and water. The IAEA had also given advice on the technical and legal details of bids for the fuel repackaging and assisted with the technical negotiations surrounding the contract itself.

After the contract was signed, the contracted companies started repackaging the spent fuel.

Figure 1: Spent nuclear fuel loading into Skoda VPVR/M

This involved opening all the barrels underwater, repackaging the spent fuel into new containers and baskets, and then loading the baskets into shipping casks. The loaded casks were vacuum dried, checked for contamination and air tightness.

Figure 2: Air tightness test of loaded and closed TUK-19 packages.

Figure 3: Gamma dose-rate measurement on Skoda

The final contract called for the permanent disposal of the high-level waste that would be generated after reprocessing of the spent fuel, since Serbia didn´t have the facilities to take back the waste after Russia recovered the still usable uranium components of the spent fuel.

How long did the entire project take? How much material was shipped back to Russia?

The entire project has taken about 8 years - from the first shipment of fresh fuel in 2002, to the final shipment ending in December 2010.

The Institute shipped 8 030 fuel elements - some 2.5 tonnes of material. Approximately 17 percent of those fuel elements contained HEU.

What will happen to the material now?

It will be reprocessed. The highly enriched uranium will be downblended to lower enrichment levels and used as nuclear power reactor fuel, thereby changing the material into a form that presents a substantially lower security risk.

The high level waste is expected to be vitrified and stored in Russia.

How many research reactors still use HEU? Why can't they just switch to LEU?

Many research reactors - around 200 in the world - still use HEU fuel, so there´s a lot of work to be done on this front. Many of these reactors can switch to LEU fuel using existing fuel, but others need to have their LEU fuel tested and approved before they can use it. Some reactors need a special high-density fuel that´s still being developed, so converting them will take time.

Are similar repatriation projects taking place or planned?

Several other countries that have either shut down their reactors or converted them to LEU fuel have shipped HEU fuel back to Russia under this programme, so progress is being made on this front, and it´s encouraging.

What is the IAEA doing to implement or assist these projects?

We assist countries with any part of their fuel repatriation or reactor conversion, from legal issues and contract negotiations to carrying out technical studies and assisting with technical issues. In the case of Serbia, we were involved with every part of the project, from advising and planning to transportation of the re-packaged fuel. There are other repatriation projects where we only advise on a single part of the process, or are only tangentially involved. The essential message to be delivered is that the IAEA stands ready to assist Member States, upon their request, with all research reactor spent fuel issues.

Figure 4: Job done (sea-going vessel loaded in Port Koper, Slovenia) .

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A Collection of Unique Challenges and Opportunities: The Research Reactor Community

The International Research Reactor (RR) Community is – in a word – diverse. Unlike nuclear power plants (NPPs) which are commercial endeavours that exist, in the vast majority of instances, for the sole purpose of electricity production; RRs are unique. Yes, there are families of similar designs such as TRIGA and WWR-M reactors; but one would be challenged to find two with similar technical/scientific missions, funding mechanisms, staffing breakdowns or management structures. Research reactor power levels span several orders of magnitude, from zero power critical facilities to highly advanced facilities operating at hundreds of megawatts. Research reactor utilization ranges from the very basic to highly complex and includes straightforward educational experiments, lifesaving medical isotope production as well as highly complex experiments involving advanced fuel testing where prototypical assemblies in tightly controlled environments are operated in extreme conditions – occasionally driven beyond normal operating limits, including to the point of intentional failure, during tests to ensure adequate safety margins.

Some facilities are highly utilized, with developed operation and maintenance schedules that track operational performance similar to many NPPs worldwide. Other facilities are significantly underutilized; a condition that can lead to decreased funding and result in a number of challenges related to safety and security. The IAEA is leading and supporting a number of activities worldwide, including several Research Reactor Coalitions, Coordinated Research Projects, and strategic and related planning activities to support Member State and individual facility efforts to improve RR utilization.

A number of RRs worldwide remain fuelled by highly enriched uranium (HEU) or irradiate HEU targets to produce medical isotopes. Many governments and non-governmental organizations identify worldwide HEU use and stockpiles as a global security risk. In cooperation with the worldwide effort to minimize the use of HEU in civilian nuclear applications, the IAEA is progressing work to convert reactors with currently available low enriched uranium (LEU) fuel, supporting work to develop advanced LEU fuel designs which will facilitate the conversion of high-power RRs that can not be converted using currently available fuel, and also helped develop indigenous LEU RR fuel manufacturing capabilities.

Similarly, the IAEA is assisting RRs repatriate both fresh and spent HEU fuel to the country of origin to help Member States reduce the risk and management burden. Support has been provided via the procurement of spent fuel shipping containers; project and procurement support to numerous, individual, repatriation projects; and technical and project oversight support to the single largest and most complex technical project in the IAEA's history. This project, at a RR near Belgrade Serbia, involves the repackaging of degraded, spent fuel and its subsequent return to the Russian Federation. The repackaging completed and the fuel was transported in the end of 2010.

The IAEA is also advancing a number of activities to support the transition of the production of medical isotopes away from the use of HEU. A Coordinated Research Project to develop small-scale indigenous Mo-99 production from LEU target irradiation or neutron activation as facilitated a number of projects within participating IAEA Member States. Work initiated in 2010 will compile a report on the status of non-HEU Mo-99 production technologies and support the transition of major Mo-99 producers via an IAEA organized International Working Group.

The fleet of operating RRs is significantly challenged by age. Over 50% of more than 230 operational RRs worldwide are more than 40 years old. The related challenges manifested themselves repeatedly since the 4th quarter of 2007 through age related shutdowns of multiple reactors heavily relied on for the global supply of medical isotopes. The IAEA is providing broad support to the related challenges via work to capture and share experiences related to Ageing Management. The IAEA also supports the planning and implementation of complex Modernization and Refurbishment capital engineering projects. A database was developed in 2009 to share experiences and information related to RR Ageing Management. A 2009 IAEA-TECDOC on RR Modernization and Refurbishment was also published to support RR managers and stimulate further information sharing within the broader RR community.

Finally, interest in peaceful applications of nuclear technologies is increasing worldwide and many Member States are approaching the IAEA to support their consideration of new RRs either to progress scientific and technology related R&D, nuclear education and skill development or as a stepping stone to more complex nuclear infrastructure deployment including burgeoning nuclear power programs worldwide. IAEA provides assistance to these efforts via group training events as well as guidance on strategic planning, facility utilization planning and justification, and project planning and implementation.

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Building a Research Reactor Before a Nuclear Power Plant: Walk Before You Can Run

Nuclear technology, both for nuclear power and for research applications, is complex. Operating and utilizing nuclear power plants and research reactors require personnel with dozens of skills sets in science, engineering, and management, most with specialized training and years of experience. They also require the support of similar infrastructure such as a regulatory body, scientific and academic communities, and basic manufacturing and technical-service capabilities.

It makes sense, then, to consider operating and utilizing a research reactor as a first step in preparation for a domestically manageable national nuclear power programme. Today, the capital cost of a research reactor ranges from less than 0.2 per cent to five per cent of that of a nuclear power plant, depending upon the respective sizes of the two facilities. In addition, the number of personnel needed to effectively operate and maintain a research reactor ranges from two per cent to about ten per cent of that required in a typical nuclear power plant – meaning operating a research reactor first allows a state to build up its human resources at a manageable pace. At present, every country in the world that operates a nuclear power plant has adopted this walk before run approach: they started their nuclear energy program with the establishment of one or more research reactors in the country.

More importantly, managing nuclear technology requires the development of a strive-for-excellence culture within the organizations involved in the licensing, operation, applications, maintenance and support of the technology, with a primary focus on safety. This is true for both nuclear power plant and research reactor applications. Members of an organization with a well-embedded strive -for-excellence culture are disciplined and well-motivated to perform work systematically, according to plans and established procedures, and to thoroughly evaluate the impact of any change before it is implemented. They communicate effectively within the organization and with stakeholders, consider safety, health and environmental protection as paramount, and have a continuous drive to improve quality. Safely operating a research reactor provides a good opportunity to introduce and nurture the strive-for-excellence culture in all participating organizations.

Member States that decide to include the nuclear power option in their future energy supply may wish to establish or join a nuclear research reactor programme as a preparatory step. The IAEA's Research Reactor Section is ready to provide advice and expertise to help Member States with decision making and organization of a research reactor project. This planning can include the identification of current and potential users, beneficiaries, and other stakeholders of the research reactor, the systematic assessment of their needs as the basis for the decision to proceed with the research reactor project, and organization of the research reactor project to ensure safety and sustainability. It should be noted that a great number of the existing research reactors in the world are currently underutilized, in many cases because of an overly narrow assessment on the need for the research reactors at the time they were acquired, and an absence of mechanisms to ensure sustainability. Countries that cannot justify a domestic research reactor on the basis of the assessment methodology mentioned above might be best served by initially participating in a regional research reactor project as an alternative.

Figure 1: The research reactor at the Atomic Institute of Austrian Universities has been well utilized for education and training.

For more information about planning for a research reactor, please visit the Research Reactor Section's homepage at http://www.iaea.org/OurWork/ST/NE/NEFW/RRS/home.html. Alternately, contact the Research Reactor Section on research.reactors@iaea.org.

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Introducing Alexander Bychkov:

The New Deputy Director General for Nuclear Energy

In January, the Department of Nuclear Energy said farewell to retiring Deputy Director General (DDG) Yury Sokolov, and in February, the IAEA welcomed Alexander Bychkov as the new DDG of Nuclear Energy. Mr Bychkov spoke to Alisa Carrigan (NEFW/RRS) and shared a little about his scientific past, where he sees the Department going, and getting out and about in Russia.

Q: Tell us a bit about your background, and your prior interactions with the IAEA.

Mr Bychkov: Well, I have never worked at the IAEA before this, though I have participated in working groups and worked on technical documents for the IAEA. My career is actually very simple – after university, I worked in the same place, from starting as a young scientist through becoming the General Director.

[Prior to coming to the IAEA, Mr Bychkov worked at the Research Institute of Atomic Reactors (RIAR or NIIAR) in Dimitrovgrad, Russia as an engineer and researcher, Head of the Fuel Technology Laboratory, Head of the Fuel Cycle Department, Director of the Chemical Technological Division and Deputy to the General Director. He became the General Director in 2006.]

Mr Bychkov: I have been a chemist since I was 13 – I took part in some scientific competitions in school, and eventually became a student at Moscow University. My speciality is molten salt chemistry, focused on pyroprocessing. I have also worked on the chemistry of plutonium, and I've participated in studies on converting plutonium into MOX fuel. I've also worked on partitioning and transmutation, and studied the pyrochemical wastes immobilization process.

Q: Since you're an expert on pyroprocessing , how do you see the future of pyroprocessing technology developing? Do you think it will become a commercially viable technology?

Mr Bychkov: For fast reactors, the technology is more acceptable, instead of aqueous technologies. Pyroprocessing uses very compact equipment, and you are able to process a lot of material and generate very compact waste. So I think, for fast reactors, the technology will be developed to a commercial level, and several states are already moving that way: Russian Federation, India, Japan, the Republic of Korea all have semi-industrial pyroprocessing programmes.

Q: As the new DDG for Nuclear Energy, what are your goals for the department? What role do you see NE playing in the IAEA's work?

Mr Bychkov: Well, my first goal is to support the changes implemented by the Director General. I think our activity in NE must be converted a bit, from our traditional activities, to more service-oriented activities, especially for newcomers. The creation of the LEU fuel bank can be a big part of that.

As a former director of a research centre, I want to increase international cooperation. I'd like to support the creation of a coalition of nuclear research facilities, and regional nuclear centres. I also think we need to help establish some standards for international cooperation and activities. Currently, there are big differences between nuclear facilities, with methods and practices. I think we can help standardize some of those practices.

Q: Is there anything you're looking forward to experiencing during your time living in Vienna?

Mr Bychkov: I like museums, and all kinds of music – from classical to rock to jazz – so I'm looking forward to seeing those sides of Vienna. When I was younger, I was also an active sportsman, especially in cross-country skiing. And I enjoy walking and hiking in the forest.

Q: What advice would you give to someone going to Russia on holiday? What's best to see or do?

Mr. Bychkov: I think small, old Russian towns are unique. Places like Suzdal and Pereslavl-Zalessky are beautiful, and you can see Russia through the ages in towns like that – especially in the Russian Orthodox churches there. There are churches from every age, from the 13th Century through the 19th Century.

Russian nature is also amazing. In the European part of the country, you can sail down the River Volga from Moscow to Samara or Saratov, and it is a beautiful trip. You stop in very interesting towns, and you can also see some very beautiful Russian nature.

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Network Synergy: International Decommissioning Network (IDN) and the Environmental Management and Remediation Network (ENVIRONET) Working Together

The word of the year for the International Decommissioning Network (IDN) and the Environmental Management and Remediation Network (ENVIRONET) was synergy. In the Waste Technology Section, both Decommissioning and Environmental Remediation belong to the same Unit, but never worked as closely as they are now. It is no surprise that when planning decommissioning, the environment needs to be taken into consideration. Conversations started early in April 2010, when two different workshops were held on similar topics, but for the different Networks, by Argonne National Laboratories (ANL) in Chicago, USA. The IAEA Scientific Secretaries, Paul Dinner for the IDN and Horst Monken-Fernandes for the ENVIRONET, realized that most of their individual Network activities could actually be complementary and so instead of holding a one-week course on each topic, they could cover more in a two-week combined course on both themes. Once they got the feedback from the participants confirming the interest in such a workshop format, the decision was made to use a synchronised approach.

As a result, during the General Conference in September 2010, the ENVIRONET and IDN organized a side event in co-operation with the UKTI (UK Trade and Investment), which focused on the importance of dealing with legacy issues and on ensuring that those building new facilities benfit from previous lessons-learned. The side event was an opportunity for the participants from 25 Member States to share their experience and bring awareness to the topic.

Later on in the year, IDN and ENVIRONET ran their Annual Meetings in parallel. In November 2010, 61 participants from 38 countries attended the meetings and had the opportunity to exchange information and experience during a joint poster session, which included presenting attendees' current issues through poster and photo gallery presentations.

Due to the great success this partnership is having so far, it is already in the 2011 plan to hold another workshop, also sponsored by ANL, that will target issues in both areas and will provide an improved approach to the challenges faced by Members States in the fields of decommissioning and environmental remediation.

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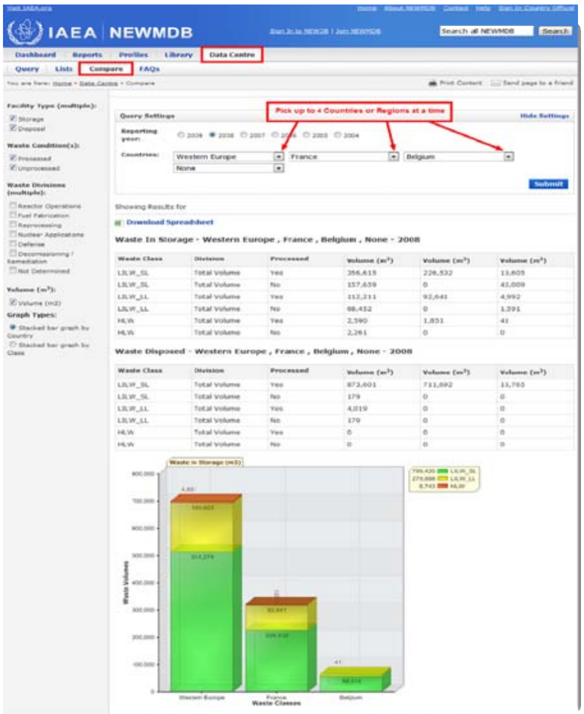
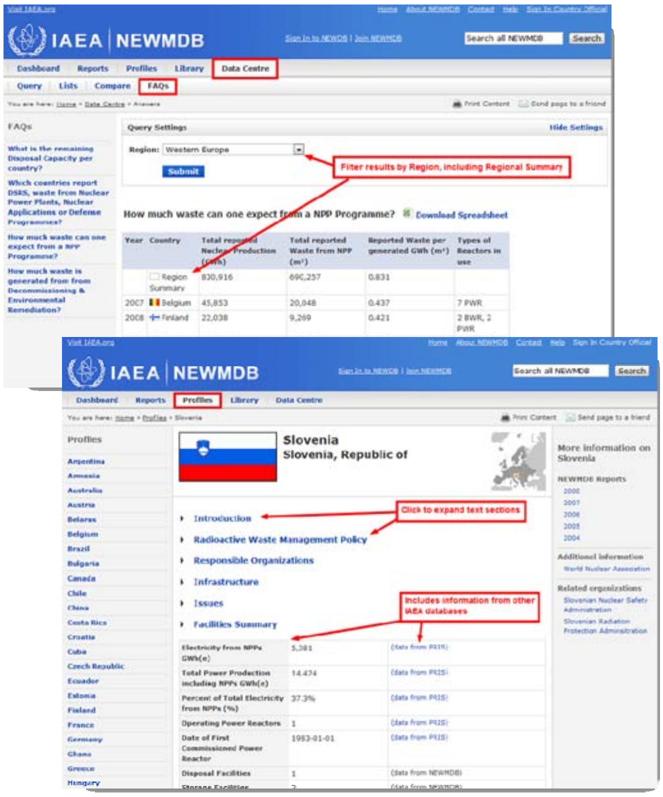
Important Updates to the Net-Enabled Waste Management Database (NEWMDB)

The IAEA has been collecting comprehensive radioactive waste management information from its Member States over the Internet since 2002 using the Net-enabled Waste Management Database (NEWMDB). In 2007, major enhancements to the system were started, and now these new features are available in a totally new web interface, with enhanced information, easier downloads, graphs of the data, and a geographical search utility based on Google Maps™. We have implemented an extended Country Profile where contextual information regarding the full scope of each Member State's radioactive waste management programme is documented and available to the public. This can be found on the Profiles tab on the new website. Information found here is either provided directly by the Member States, or is compiled from other official sources.



As part of the effort to make this database less about data and more about accessible information, we have prepared standard analytical charts and tables, framed around frequently sought-after information or questions, such as "How much waste is generated by nuclear power?" or "What is the remaining disposal capacity per country?". We plan to add more of these frequently asked questions (which can be found under FAQs on the Data Centre Tab) as they provide an accessible and valuable way to view and understand the data contained in the NEWMDB. These are the real questions that the public, stakeholders, practitioners, politicians and policy-makers really want answered.



An important capability of the NEWMDB and a feature at the core of its design is the translation of National Waste Classification schemes into a standard scheme based on the IAEA's recommendations (these can be found in IAEA GSG-1, *Classification of Radioactive Waste*, 2009, available on the NEWMDB Library Tab of the IAEA Publications Website). In reality, most countries have their own schemes for classifying radioactive waste, and this creates an immediate problem to anyone interested in understanding local, regional, and global situations with respect to the generation, management, and disposal of radioactive waste. By translating the raw data into a consistent classification scheme, comparisons can be made and global inventory estimates are facilitated. To take full advantage of this capability, a new feature has been added (called Compare under the Data Centre Tab) to allow direct, on-screen comparison (with tables and graphs) of any country or region to any other country, region, or to the global status of radioactive waste storage and disposal.

We hope to receive feedback and suggestions for more improvements and we sincerely believe that these improvements will help to improve public awareness and understanding of radioactive waste management issues worldwide.

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Zion NPP: Interesting Decommissioning Strategy

The Zion case illustrates one approach to decommissioning which, if still unique, may find some followers, at least in the USA. The Zion-1 and -2 units PWRs, located near Chicago, Illinois, (Fig 1) were licensed to operate in 1973 and were permanently shut down in 1997 and 1996, respectively. The plant was placed in a Safe Enclosure, and was scheduled to begin active decommissioning and dismantling in 2017. Exelon initially intended to dismantle the plant by 2032. However, it was soon realized by the licensee (Commonwealth Edison, now part of Exelon Corporation) that the cost of surveying and maintaining the shut down plant was high, some 10 million US$ a year. The licensee had funds for decommissioning of almost one billion US$ in mid-2010 after recovering from the crisis that hit financial markets in late 2008.

Energy Solutions, a large US waste management and demolition company, proposed a turn-key fixed price bid of about one billion US$, and believes they can do the job successfully. As they own the waste disposal facility in Utah, they have some additional margin for profit by only charging themselves their direct cost for disposal, and therefore increase their profit. It also puts them at the forefront for bidding other opportunities if they should arise.

The US Nuclear Regulatory Commission has granted Energy Solutions control of plant's license. The firm is set to clean up the nuclear site by 2020, including permissions and environmental remediation, and return license and unrestricted site control to Exelon. The spent reactor fuel will be stored onsite in dry cask storage. In this way, the decommissioning and site clean-up is expected to be accelerated by at least 12 years ahead of schedule. The decommissioning project will be the largest NPP decommissioning ever undertaken in the USA, requiring an average of 200 skilled workers each year, most of them local, and a peak workforce of up to 450.

No doubt, having the waste disposal facility readily available will be a major asset for Exelon. For example, large sections of the plant will be dismantled and moved by rail to the disposal site, where they will be crushed and compacted. This technique, nicknamed rip and ship is expected to effectively control expenses. The Utah facility normally charges US$ 25-100 per ft^3 (0.028 m^3) for waste disposal. Some 4 million ft^3 (112 000 m^3) of Zion waste is expected to be moved to Utah and disposed of there. Thus disposal alone could cost another company as much as 400 million US$.

From the worldwide perspective of the IAEA, the Zion case confirms the overall trend towards immediate or accelerated dismantling rather than decades of safe enclosure followed by deferred dismantling. From another angle, it confirms that many utilities are reluctant to embark directly in costly decommissioning projects, since they may not have adequate skills and resources for these projects. Finally, the Zion deal confirms that the funding mechanism in force in the USA is adequate to support actual NPP decommissioning projects.

Sources: Inside NRC, 13 Sep 2010, Exelon, Energy Solutions close on novel Zion decommissioning deal; Engineering News- Record, 13 Sep 2010, Energy Solutions Inks Contract for Unique D&D Plan at Zion; The Wall Street Journal 1 Sep 2010, Nuclear Plant's Tear -Down is Template)

Figure 1: Zion-1 and -2.

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Dismantling of Legacy Nuclear Submarines

The programme of legacy nuclear submarine dismantlement in Russia is almost complete. Before this programme started, two hundred decommissioned nuclear submarines flocked shipyards and harbors of North-West and Far East Russia posing significant threat to the environment and raising concerns over security of spent nuclear fuel contained therein. By the end of 2010, Russia and its international partners have defueled and dismantled 191 decommissioned nuclear submarines. International partners have funded one third of the dismantlement programme: USA - 32 submarines, Canada -15, Japan – 6, Italy – 5, Norway - 4 UK – 4. Only one legacy submarine in the North West and four in the Far East of Russia are waiting for dismantlement.

The programme starts with transporting old submarines, many of them having feeble buoyancy, to dismantlement shipyards, sometimes up to a distance of 2 500 km. Nuclear fuel is then removed from the reactors (usually two reactors per submarine) by special retrieval machines and placed into casks that are transported by ship and then by train to the fuel reprocessing plant. In some cases, decontamination of a submarine is required prior to defueling. This is followed by treatment of radioactive waste generated at the shipyards. The submarine is then placed in a special dock and gradually dismantled with the help of gas cutters. Scrap metal is compacted and sent for recycling.

A big reactor compartment with two reactors inside is left over. These compartments are sealed and transferred by ship to intermediate storage facilities. One of these facilities, built with German funding in North West Russia, has already accumulated over 40 reactor compartments. A second facility is currently being built by Russia with Japanese assistance. After about 70 years of storage, when the activity inside these reactors has significantly decayed, the compartments are to be further cut into relatively small sections and sent to a disposal facility.

International partners implementing the above programme are united in the Contact Expert Group (CEG) for nuclear legacy initiatives in Russia under the auspices of the IAEA. At their meetings, the CEG members exchange information, plan, and coordinate their activities with a stress on nuclear and radiation safety. CEG members are now concentrating their efforts on safe removal of nuclear legacy fuel from former navy bases and also creation of regional centres for radioactive waste conditioning and storage.

Figure 1: Beginning of dismantlement.

Figure 2: Initial stages of dismantlement.

Figure 3: Submarine reactor compartments at the storage facility.

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IAEA Spent Fuel Performance Assessment and Research (SPAR-III) Coordinated Research Project (CRP)

The 1st Research Coordination Meeting (RCM) of the Spent Fuel Performance Assessment and Research (SPAR-III) CRP was held on 8-12 November in Tokyo, Japan. 12 representatives with research agreements or contracts and 9 observers participated in the RCM. The RCM was hosted by Central Research Institute of Electric Power Industry (CRIEPI).

Specific research objectives of the SPAR-III CRP include fuel and materials performance evaluation under wet and dry storage, surveillance and monitoring programs of spent fuel storage facilities, and collection and exchange of relevant experience of spent fuel storage. Currently, 9 member states and 1 international organization are participating in the SPAR-III CRP. The purpose of the meeting was to discuss the plans of the proposed research of the individual participants and its relationship to the overall objectives of the CRP and to promote interaction between the participants through discussion.

During the meeting chaired by F. Takats from Hungary, participants presented national updates and research results on spent fuel performance which can be summarized as follows:

Interim storage of spent fuel has become a key element of the nuclear fuel cycle and provides flexibility and technological benefits in spent fuel management. It is recommended that R&D programs should be devoted to confirm and extend the safe storage and transport period.

Concerns about high burnup cladding are an increase in hydrogen concentrations in cladding and an increase in hydrides precipitated radially. Hoop ductility of high burnup cladding may be lower due to hydride reorientation causing cladding fracture during side drop. It is necessary to acquire the fuel rod behavior by dynamic load impact tests on high burnup spent fuel rods and it is needed to map ductile-to-brittle transition temperature against cladding materials, drying cycles and burnup.

Japanese utilities are planning to conduct a long-term storage test for maximum 60 years by placing PWR fuels in a test container which simulates temperature and internal gas of actual casks to accumulate knowledge and experience on long-term integrity of PWR spent fuels during dry storage, while another long-term demonstration project with high burnup fuel to be initiated in USA.

It was discussed that major topics of the CRP report will be fuel assembly degradation and storage facility component degradation in wet and dry storage. Participants identified their potential contributions to the CRP technical report and agreed to provide the intermediate results by the next RCM. Participants ask the IAEA secretariat to invite experts from major players such as Russia and Canada as observers or consultants.

On 10 November, the participants visited Hitachi GE Nuclear Energy and Central Research Institute of Electric Power Industry (CRIEPI) Abiko center in the morning. Hitachi GE Nuclear Energy has a metal dry storage cask manufacturing center and CRIEPI Abiko center has a cask performance test laboratory. In the afternoon participants visited Tokai-2 NPP dry storage facility in Tokai-mura, Ibaraki Prefecture. Tokai-2 power station, (1 100 MW(e) BWR) is the first large-scale nuclear power plant in Japan installed in 1978 having a dry storage facility with 24 dry storage metal casks.

Through the 1st RCM of SPAR-III CRP, technical discussion on research plans and results of participants was initiated, interaction between the participants was facilitated, and information on national R&D programs was exchanged. Cooperative interaction between participants and the IAEA secretariat has been enhanced as a result of presentations, discussions, hospitality and a technical tour during the first RCM. It was decided tentatively that the next RCM will be held in May, 2012 in Charlotte, NC, USA, hosted by US Electric Power Research Institute (EPRI).

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Burnup Credit (BUC) Applications for Spent Fuel Management

In the last 20 years, burnup credit (BUC) has been frequently applied in criticality safety analysis of spent nuclear fuel systems instead of the fresh fuel assumption usually made in the past. With the steady development of calculation methods, it became possible to take credit for the reactivity reduction associated with the fuel burnup process, hence reducing the analysis conservatism associated with the fresh fuel assumption while maintaining an adequate criticality safety margin. Therefore, more and more countries are interested in applying BUC, in particular those countries developing nuclear energy programmes.

Spent fuel management is a common and costly activity for all operators of nuclear power plants. One possibility to achieve a reduction in fuel cycle costs while increasing safety margins associated to the different processes is to implement burnup credit in spent fuel management systems. In fact, in many countries, burnup credit is already applied to transport systems, wet and dry storage facilities, and components of reprocessing plants. For spent fuel disposal as well as reprocessing of some advanced fuel designs, burnup credit is considered to be important in demonstrating viable approaches.

In 1997, the IAEA initiated a task to monitor the implementation of burnup credit in spent fuel management systems, to provide a forum to exchange information, to discuss the matter and to gather and disseminate information on the status of national practices of burnup credit (BUC) implementation in the Member States. The IAEA started this active programme with an advisory meeting in 1997,, followed by major meetings on BUC held in Vienna in 2000, Madrid in 2002, and London in 2005, as well as an international workshop in Spain in 2009. Moreover, the IAEA has contributed to the organization of BUC training courses held in different countries.

The 2011 International Workshop on Burnup Credit Criticality Calculation Methods and Applications will take place on 25-28 October 2011 in Beijing, China. The objective of the workshop is to provide information about the fundamentals of BUC criticality analyses, as well as to present and discuss recent developments in BUC methodologies and applications. The workshop will focus on safety-related, operational and regulatory aspects. It is also intended to foster the exchange of international experience in licensing and implementation of BUC applications.

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The Borehole Disposal for Disused Sealed Radioactive Sources

Radioactive sources are widely used in various industrial, research and medical applications. At the end of their life, when they are no longer suitable for their intended purpose and become a financial liability, disused sealed radioactive sources (DSRS) need to be returned to the manufacturer, securely stored or disposed of in the Member State where they were used. Appropriate tracking, conditioning, storing and the eventual disposal of disused sources is costly, and for high activity sources also technically difficult. For countries without research reactors or nuclear power generating facilities, DSRS are often the only type of radioactive waste that needs to be managed. Many of these countries are well developed and technically sophisticated, but sometimes no disposal route for DSRS has yet been identified. Other countries have minimal financial, human and technical resources and hence have an added difficulty in assuring the safety of long-term management and identifying disposal options for their inventory of DSRS. Consequently, the IAEA has developed a relatively simple and economically viable disposal solution for use by any interested country. This option is termed the Borehole Disposal System (BOSS). It integrates DSRS handling and conditioning on the surface with emplacement of the DSRS in an engineered borehole, which would be situated in a suitable geological environment. If properly planned and implemented, this option will result in the safe and secure disposal of modest quantities of all types of DSRS.

The BOSS concept consists of drilling one or more 260 mm diameter boreholes to a depth of about 100 m, in which disposal containers would be carefully emplaced and backfilled with cement or other suitable material. Each disposal container would contain a source within a stainless steel capsule within a containment barrier. Emplacement would commence at the bottom of the borehole and would continue towards the surface with an appropriate separation distance between containers. No disposal would be advised within 30 m of the ground surface, and site characterisation would ensure that the borehole would not be situated at a location where there are high rates of erosion or the possibility of other types of natural disturbance.

Evaluation work carried out on behalf of the IAEA included consideration of container materials, backfill materials and a generic post–closure safety assessment. The post–closure safety assessment and the associated derivation of activity limits showed that the borehole disposal concept provides an appropriate degree of long-term safety. BOSS does not require an extended period of institutional control and, due to its small footprint, the likelihood of direct human intrusion into the borehole is small. An international peer review team positively assessed the technical feasibility, economical viability and the overall safety of the concept and thus the development phase of the project has been concluded.

The IAEA is now ready to support an actual demonstration of the concept by providing technical assistance to interested Member States. The IAEA will also provide technical assistance through expert missions to provide advice and guidance and to support the retrieval and conditioning of sources. Basic prerequisites to implementation include:

- a suitable legal and regulatory framework is in place;
- responsibilities for regulation and implementation of BOSS have been allocated to appropriately competent bodies;
- a national inventory of radioactive waste (including DSRS) has been compiled;
- there is a clear commitment from national authorities to support the siting, approval and

implementation of BOSS through an appropriate national radioactive waste management policy or strategy.

In late 2010 an expert mission was undertaken to Ghana where the Ghanaian Atomic Energy Commission is intending to initiate pre-disposal work in 2011, including the characterization of a preferred disposal site. Expressions of interest have also been received from other Member States.

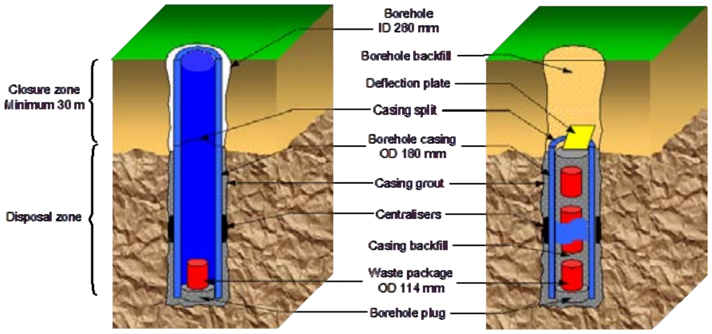

Figure 1: Schematic representation of the emplacement borehole.

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A New Tool for the reporting of National Radioactive Waste and Spent Fuel Inventories

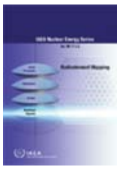
Many Member States that provide data concerning spent fuel and radioactive waste management to the IAEA have asked for a way to extract that data into a format that is useful for National Reporting, particularly for the Joint Convention on the Safety of Spent Fuel and the Safety of Radioactive Waste (Joint Convention). The Joint Convention obligates its Contracting Parties to provide a comprehensive overview of their spent fuel and radioactive waste management infrastructure and inventories every three years. Much, if not all, of this data is already provided voluntarily to the IAEA and stored in a set of databases, namely, the Net-Enabled Waste Management Database (NEWMDB), Nuclear Fuel Cycle Information System (NFCIS), Research Reactor Database (RRDB), and the Power Reactor Information System (PRIS).

By linking these databases, a powerful reporting tool has been created without the need for additional data collection. Using data already supplied and verified by Member States for consistent reporting is the central idea behind the data presentation tool (or DPT). The DPT is a special report generator designed specifically to assist Contracting Parties with the writing of national radioactive waste and spent fuel inventory reports. The DPT enables Contracting Parties to extract their data back out of the system in a way that complies with the guidelines and requirements for National Reports under the Joint Convention. The system is currently available to authorized National Contact Points for the Joint Convention who already have access to the JCWeb online application, and can be accessed easily at this simple URL: http://dpt.iaea.org/

Users should note that some data are less frequently updated than others. For example, spent fuel inventory and facility information and research reactor facility status are currently not as frequently updated as radioactive waste management information. It is important for Member States to update their respective information in these systems in order to make the DPT have the maximum value for the Member States. We hope that after the Contracting Parties have seen what the system can do, that they will endeavour to update all of their information as soon as possible. For questions or comments on the DPT, please contact John Kinker.

John Kinker (J.Kinker@iaea.org)

Recent Publications



IAEA Nuclear Energy Series No. NF-T-1.3
Radioelement Mapping (2010) **NEW!**

IAEA Nuclear Energy Series No. NG-T-4.3
Cost Aspects of the Research Reactor Fuel Cycle (2010) **NEW!**

IAEA Nuclear Energy Series No. NG-T-4.5
Technical Features to Enhance Proliferation Resistance of Nuclear Energy Systems (2010) **NEW!**

IAEA-TECDOC-1625
Research Reactor Modernization and Refurbishment (2009) **NEW!**

IAEA-TECDOC-1630
Use of Reprocessed Uranium: Proceedings of a Technical Meeting held in Vienna, 29-31 August 2007(2010) **NEW!**

IAEA-TECDOC-1645
High Temperature Gas Cooled Reactor Fuels and Materials (2010) **NEW!**

IAEA-TECDOC-1647
Progress in Radioactive Graphite Waste Management (2010) **NEW!**

IAEA-TECDOC-1648
Assessment of Partitioning Processes for Transmutation of Actinides **NEW!**

IAEA-TECDOC-1649
Delayed Hydride Cracking of Zirconium Alloy Fuel Cladding **NEW!**

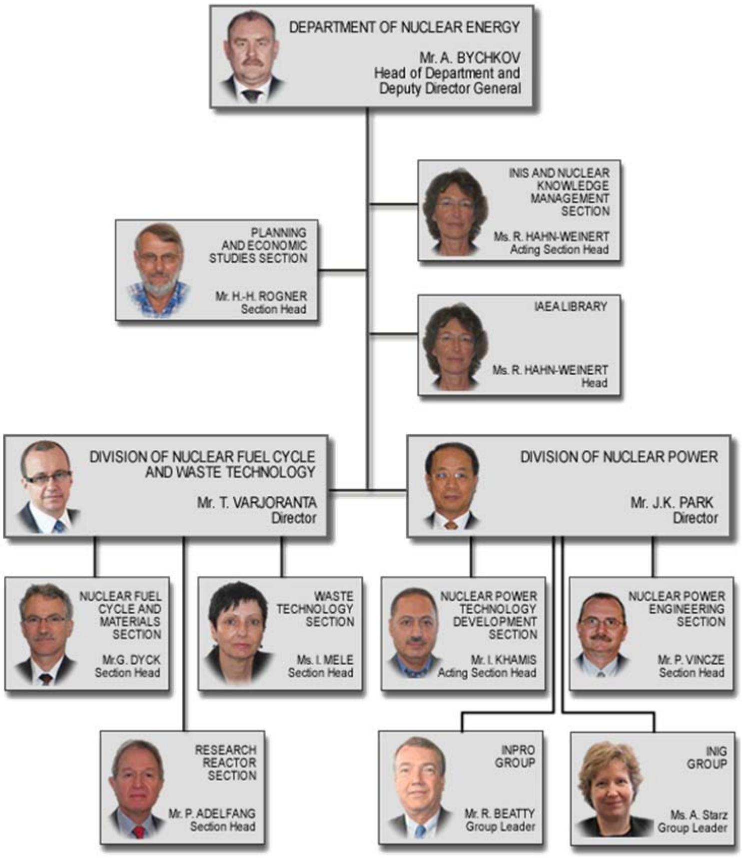
IAEA-TECDOC-1654
Advanced Fuel Pellet Materials and Fuel Rod Design for Water Cooled Reactors **NEW!**

Upcoming Meetings in 2011

Date	Title	Place	Contact
23-27 May	TM on hot-cell PIE and pool-side inspection of nuclear fuel	Smolinice Slovakiaa	V.Inozemtsev@iaea.org
30 May- 3 June	TM on design, manufacturing and radiation behaviour of fast reactor fuels	Obninsk Russian Fed.	V.Inozemtsev@iaea.org
14-16 June	Joint OECD/NEA-IAEA Uranium Group Meeting (46th Meeting)	Vienna Austria	M.Fairclough@iaea.org
20-22 June	TM on uranium provinces and mineral potential modelling	Vienna Austria	H.Tulsidas@iaea.org
22-24 June	Annual meeting of the Technical Working Group on Research Reactors (TWGRR)	Vienna Austria	P.Adelfang@iaea.org
27-30 June	TM on regional cooperation in spent fuel and radioactive waste management in Southeast Asia	Jakarta Indonesia	H.Ryu@iaea.org
27 June- 1 July	TM on the use of simplified and detailed mathematical models in environmental remediation	Vienna Austria	H.Monken-Fernandes@iaea.org
28-30 June	TM on advanced partitioning processes	Vienna Austria	U.Basak@iaea.org
4-8 July	TR on the application of mathematical model in environmental remediation projects	Vienna Austria	H.Monken-Fernandes@iaea.org

Division of Nuclear Fuel Cycle and Waste Technology (NEFW) WebSite Links

Division Introduction - NEFW Home: http://www.iaea.org/OurWork/ST/NE/



Nuclear Fuel Cycle and Materials Section (NFCMS)

- Main activities
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_home.html
- Technical Working Group on Nuclear Fuel Cycle Options (TWGNFCO)
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_twgnfco.html
- Technical Working Group on Water Reactor Fuel Performance and Technology (TWGFPT)
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_twgfpt.html
- Integrated Nuclear Fuel Cycle Information System (iNFCIS)
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_infcis.html

Waste Technology Section (WTS)

- Main activities
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_home.html
- International Radioactive Waste Technical Committee (WATEC)
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_watec.html
- Technical Group on Decommissioning (TEGDE)
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_tegde.html
- Databases (NEWMDB, DRCS)
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_information.html

Research Reactor Section (RRS)

- Main activities
  http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_home.html
- Technical Working Group on Research Reactors (TWGRR)
  http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_twgrr.html
- Research Reactor Database
  http://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?rf=1
- Research Reactor Ageing Database
  http://www.iaea.org/OurWork/ST/NE/NEFW/AD/index.html

Impressum

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