IAEA
International Atomic Energy Agency

Fuel Cycle and Waste Newsletter

A newsletter of the Division of Nuclear Fuel Cycle and Waste Technology
Vol. 6, No. 2, August 2010
ISSN 1816-9287

http://www.iaea.org/OurWork/ST/NE/NEFW/index.html

Contents

Division of Nuclear Fuel Cycle and Waste Technology
Department of Nuclear Energy
IAEA
P.O.Box 100
Vienna International Centre
1400 Vienna, Austria
Tel : +43 1 2600 25670
Fax: +43 1 2600 29671

International Conference: Longer Spent Fuel Storage Times pose New Challenges

The International Atomic Energy Agency, in cooperation with the OECD Nuclear Energy Agency, held an International Conference on 'Management of Spent Fuel from Nuclear Power Reactors' from 31 May to 4 June 2010 in Vienna. The conference was attended by 207 participants and observers from 37 countries and 3 international organizations.

The first day of the conference highlighted emerging initiatives that have significant potential to shape and influence future spent fuel management approaches in Member States. Mr. A. Kakordkar, India, served as Conference President. The conference was opened by Mr Y. Sokolov, IAEA Deputy Director General, Department of Nuclear Energy, Mr. U. Yoshimura, Deputy Director for Safety and Regulation, OECD NEA, Mr. W. Graf, Director of Spent Fuel Management Department, GNS mbH Germany and Mr. A. Kakodkar.

The opening session was followed by a session on '*Strategic Issues and Challenges in Spent Fuel Management*' in which national spent fuel management strategies were presented by delegates from Russian Federation, Japan, USA, India, Spain, Germany, UK, and Canada. Spent fuel management for smaller programmes and newcomer states were also presented in the following session by delegates from Jordan, Chile, South Africa, and Egypt.

Increasing and Important Challenges Ahead!

From the 1st of July, it has been my pleasure to be the new skipper of the highly motivated and service oriented division of Nuclear Fuel Cycle and Waste Technologies. I want to thank Hans Forsstroem, my predecessor, for the excellent work he did over the years. Hans, you are missed!

Short, medium and long term horizons look very interesting for all of us in our Member States and here in the IAEA working in the nuclear fuel cycle, waste technology and research reactor areas. Important challenges are growing – and continue to do so for years to come - in the chancing nuclear world both in the existing and new nuclear programs. We have to pay constant attention to the changing operational environment to be able to meet and respond to the needs of our Member States in a timely fashion.

I would like to mention a few of the growing challenges we will address:

***Uranium production cycle*:** even uranium resource base is adequate to meet the projected requirements, the challenge to develop environmentally sustainable mining operations and to bring increasing quantities of uranium to the market in a timely fashion, must not be underestimated or misjudged. Assistance and attention is more and more needed in relation to new mines in less prepared locations.

***New demands for spent fuel management and disposal*:** Spent fuel with higher burnups will have to be stored for longer periods (100 years and beyond) than initially intended. Every country operating a nuclear plant needs access to waste disposal. We are likely to give higher priority to spent fuel and disposal issues as they are often seen as creating potential risks and unsolved problems and have a high public visibility. However, there are lots of good industrial practices in spent fuel and nuclear waste management. Therefore, we will also look at identifying and sharing good practices. In addition to being useful to the technical community, hopefully we are able to de-mystify some of the public's disbeliefs and misperceptions so often attached to the waste issues. Public relations stay high in the Agenda.

Low and intermediate level waste management has been established in several countries. However, support will be needed to develop pre-disposal technologies further and to implement disposal in additional countries. For countries with limited low, intermediate or high wastes or without access to geologically suitable disposal sites, multinational disposal at sites with good geology might be an option.

More decommissioning and remediation: The industry will grow. We can help improve the flow of knowledge and experience among those engaged in remediation and decommissioning, and can encourage organizations in developed countries to provide assistance to those with lesser capabilities. We emphasize that main conditions for successful decommissioning are created already in the design of a plant.

***Ageing of research reactors*:** In addition to ageing management, support is needed in converting more research reactors from using highly enriched uranium to low enriched uranium, repatriation of the fuel as well as assurance of Mo-99 production for medical purposes. New approaches to utilize better research reactors need our support .

***Fast reactors and innovations*:** Looking more into the future, innovations and developments are needed for sustainable solutions. We will support and catalyze work in Advanced Nuclear Fuels and Fuel Cycles aiming at safe, proliferation resistant and economically efficient nuclear fuel cycles, while minimizing waste and environmental impacts.

We will do our best to serve our Member States by providing in a timely fashion practical guidance, review services, training, technology development and innovations and up-to-date global information through our much used databases. Knowing your needs, sharing and working together will be our keys to your success.

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

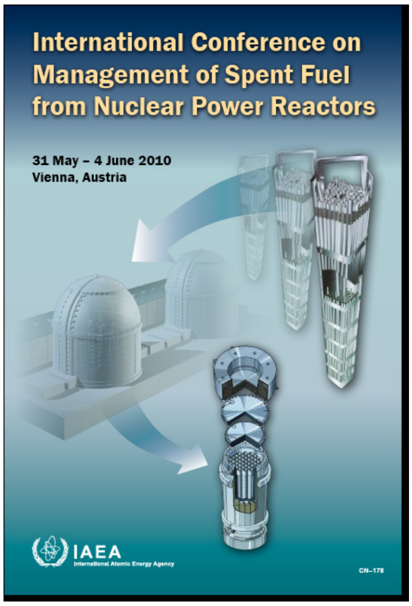
Safety issues of spent fuel management were discussed on 1 June in the round table discussion on regulatory framework for spent fuel management and the following session for safety and licensing of spent fuel storage and transportation. Panellists from Switzerland, Japan, Chile, Spain and Sweden, representing various stakeholders, had discussions in the round table session for stakeholder issues. Technology-related sessions from 2 June to 4 June addressed current issues on technological innovation for spent fuel storage, fuel and material behaviour, managing past and damaged spent fuel, operating experience in wet and dry storage, managing high burnup and MOX, fast neutron reactor spent fuel, spent fuel reprocessing, very long-term storage and the disposal of spent fuel.

The conference concluded on 4 June with a round table discussion on future strategies in spent fuel management,

chaired by Mr. T. Taniguchi, IAEA Deputy Director General, Department of Nuclear Safety and Security who also closed the meeting. The summaries by the Conference President reflected the most important conclusions and findings as follows:

- Spent fuel will have to be stored for longer periods than initially intended and storage times may have to be extended up to 100 years and beyond, the challenges presented by this are compounded by modern fuel being discharged at higher and higher values of burnup;
- While it appears that spent fuel is being managed safely, aging management measures and standards should be continually reviewed to reflect new knowledge and experience gained and it would be valuable to develop more guidance for extended long-term storage;
- The IAEA should provide newcomer countries with all necessary information related to spent fuel management including the long term issues and disposal;
- Multilateral solutions for storage, reprocessing and disposal in which there are sharing mechanisms between countries might help smaller countries;
- To address the interface issues between storage and transport, a holistic approach to regulation is needed in which the different timescales for transport and storage licensing are accommodated;
- The development of fast reactors and advanced fuel cycles brings additional considerations to the management of spent fuel;
- Every country operating a nuclear plant needs access to disposal, whether the country has opted for an open or closed fuel cycle. There is an urgent need to move towards final disposal options. Fortunately, repository projects in Finland, France and Sweden are moving to licensing stages.

Further information can be found at http://www-ns.iaea.org/meetings/rw-summaries/vienna-2010-mngement-spent-fuel.htm



Gary Dyck (G.Dyck@iaea.org)

Xuxin Zou (X.Zou@iaea.org)

Hojin Ryu (H.Ryu@iaea.org)

Argentina's Innovative Approach to Spent Fuel Storage

With the assistance of the IAEA, Argentina is working to deploy an innovative spent fuel storage system. IAEA has procured equipment and installation services according to an Argentinean design for a system that stores spent research reactor (RR) fuel in individual spools (Figure 1), stacked vertically (Figure 2) in a deep storage pool. The storage facility, located outside of Buenos Aires, was originally constructed for another purpose. But an eighteen meter deep, narrow pool is now home to the Comisión Nacional de Energía Atómica (CNEA) designed research reactor spent fuel storage equipment.

The system works by remotely rotating spools to align

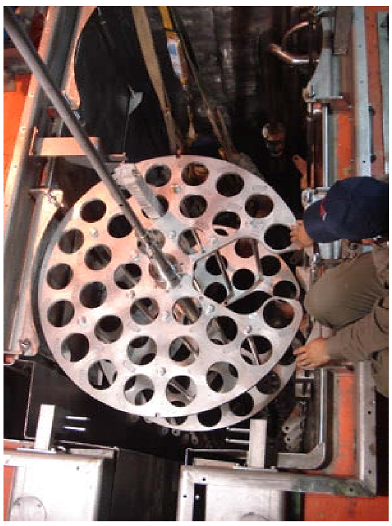


Figure 1 – Storage spool

Figure 2 – Stacked spools with a dummy fuel assembly

cut-out sections in order to access fuel storage locations at various levels. The tooling, rotation and alignment mechanisms were also part of the supply. Each spool has 32 storage locations. The project installed 13 storage spools, but there is room in the pool for an additional 6 in the future (Figure 3).

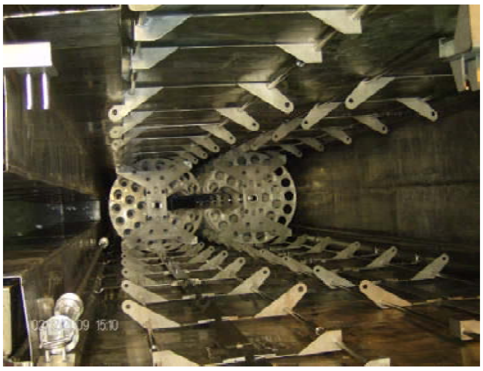


Figure 3 – All spools installed

IAEA support for this project was implemented via a national Technical Cooperation project. The final deliverable was accepted during a site inspection visit in December 2009.

CNEA is currently working to obtain final regulatory approval prior to loading fuel into the storage system.

Ed Bradley (E.Bradley@iaea.org)

New Red Book: Latest Data Shows Long-Term Security of Uranium Supply

Uranium production and demand are both on the rise. Exploration efforts have increased substantially in the last few years. The total identified resources have grown to be sufficient to supply the current reactor fleet for over 100 years. These are among the conclusions of *Uranium 2009: Resources, Production and Demand*, commonly referred to as the 'Red Book', just published by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA).

Worldwide exploration and mine development expenditures have more than doubled since the publication of the previous edition, *Uranium 2007: Resources, Production and Demand*. These expenditures have increased despite declining uranium market prices since mid-2007.

The uranium resources presented in this edition, reflecting the situation as of 1 January 2009, show that total identified global resources amounted to 6 306 300 tU. This represents an increase of about 15% compared to 2007, including those reported in the high-cost category (<US$260/kgU or <US$100/lbU_3O_8), although total identified resources have increased overall, there has been a significant reduction in lower-cost resources owing to increased mining costs. **At 2008 rates of consumption, total identified resources are sufficient for over 100 years of supply**.

The recognition by an increasing number of governments that nuclear power can produce competitively priced electricity that is essentially free of greenhouse gas emissions, coupled with the role that nuclear can play in enhancing security of energy supply, increases the prospects for growth in nuclear generating capacity, although the magnitude of that growth remains to be determined.

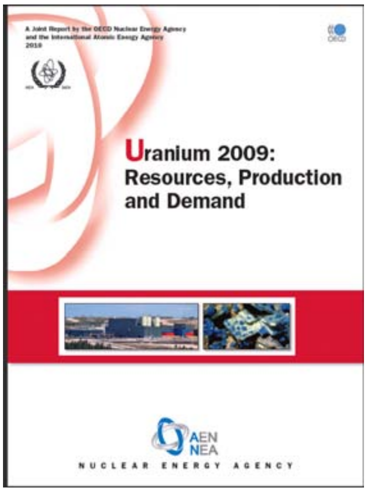
According to capacity projections used in Red Book, by the year 2035, world nuclear capacity is projected to grow to between 500 and 785 GW(e) net. Accordingly, world reactor-related uranium requirements are also projected to rise. As observed in the past, increased investment in exploration has resulted in important discoveries and the identification of new resources. It is foreseen that, if market conditions improve further, additional exploration will be stimulated leading to the identification of additional resources of economic interest.

Even in the high-growth scenario to 2035, less than half of the identified resources described in Red Book would be consumed. The challenge remains to develop mines in a timely and environmentally sustainable fashion as uranium demand increases. A strong market will be required for these resources to be developed within the time frame required to meet future uranium demand.

In addition, current projections of uranium mine production capacities could satisfy projected high-case world uranium requirements until the late 2020s. However, given the challenges and length of time associated with increasing production at existing mines and opening new mines, it is unlikely that all production increases will proceed as planned. As a result, secondary sources of previously mined uranium will continue to be required, complemented to the extent possible by uranium savings achieved by, for example, specifying lower tails assays at enrichment facilities and technical developments in fuel cycle technology.

While the status of supply and demand is considered from the perspective of today's technologies, it should be recognized that the deployment of advanced reactor and fuel cycle technologies can positively affect the long-term availability of uranium and could conceivably extend it to thousands of years.

This is the 23rd edition of the Red Book, which is currently published every two years. It is a perpetual IAEA bestseller and is available for purchase online through the NEA website (www.nea.fr).



Uranium 2009: Resources, Production and Demand, A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, OECD, Paris 2010.

Jan Slezak (J.Slezak@iaea.org)

Technical Working Group Urges More Focus on the Future of the Nuclear Fuel Cycle

The eighth meeting of the Technical Working Group on Nuclear Fuel Cycle Options and Spent Fuel Management (TWGNFCO) was convened in Vienna 8-11 June 2010. 13 participants from 12 Member States chaired by Mr. Y. Chang from USA contributed to three round table discussion sessions and reviewed IAEA work and plans in the areas of spent fuel management and advanced fuel cycle.

A discussion session on proliferation resistance confirmed that incorporating proliferation resistant characteristics in advanced fuel cycle technologies is important. It was recognized that the methodologies developed in the INPRO and GIF are useful tools for assessment of the proliferation resistance of fuel cycles and fuel cycle facilities. There is also a strong need for development of improvements in the technical and institutional contributions to the safeguardability of fuel cycle facilities. Members recommended that the proliferation resistance assessments should be coordinated with the Safeguards Department in order to make sure the importance of safeguardability is emphasized.

A session on innovation addressed advanced fuel and fuel cycle technologies. It was found that much progress has been made in advanced reprocessing technologies, in particular in partitioning of minor actinides, with a goal of transmuting them in fast reactors. These advanced separations technologies are not only applicable to transmutation scenarios, but will also likely drive the next generation of improvements to main-stream fuel recycling.

Multilateral cooperation was discussed and highlighted the need for multilateral cooperation in the back end of the fuel cycle among the states with established nuclear infrastructure as well as among newcomer states. It was recommended that the IAEA should take initiative to facilitate the formulation of an international fuel cycle centre concept focused on the back end of the fuel cycle by reviewing existing studies and inputs from workshops.

The following key conclusions were also agreed upon at the meeting:

The back end of the fuel cycle is an important factor for the public acceptance of the expanded use of nuclear energy;

The LWR once-through cycle is becoming a de facto reference fuel cycle in some member states. Establishing the viability of long-term storage of spent fuel and subsequent direct disposal is therefore very important;

Assessment of the technical feasibility of maintaining spent fuel integrity in long-term storage should be given priority in the IAEA's programs;

The fast reactor has emerged as an important option for long-term nuclear sustainability.

Much progress has been made in advanced reprocessing technologies, in particular in partitioning of minor actinides, with a goal of transmuting them in fast reactors.

The next generation of fuel recycling plants will likely incorporate advances currently being made in aqueous separation technologies.

There is a strong need for development of improvements in the technical and institutional contributions to the safeguardability of fuel cycle facilities.

Multilateral cooperation in the back end of the fuel cycle is important. However, 'not in my back yard' syndrome would be a major barrier even to initiate discussions in this regard. Therefore, the IAEA should take initiative to facilitate the formulation of an international fuel cycle centre concept focused on the back end of the fuel cycle by reviewing existing studies and inputs from workshops.

The next meeting is scheduled for 7-10 June 2011 at the IAEA, Vienna.

Gary Dyck (G.Dyck@iaea.org)

Low Grade Uranium Ore offers New Potential

Increasing interest in nuclear power worldwide has lead to rising uranium demand, and in turn, the price of uranium concentrates. The consequent uranium industry revival has prompted renewed uranium exploration and mining activities in several countries while the short fall of uranium supply has been complemented by secondary supply. New sources of primary uranium will focus on exploration and exploitation of lower grade ore bodies, and so resource projects will seek low energy mining methods, as well as lower intensity ore treatment routes, to minimize yellowcake recovery costs from these deposits.

The Technical Meeting for Low Grade Uranium Ore brought together engineers and practitioners with representatives of member states to look to the future of uranium project discovery, development, operation and closure. Uranium projects have generally mined the higher grade ore bodies due to depressed prices for yellowcake, and ore grades of future projects will decline on average. The previous IAEA meeting to discuss low grade uranium ores was held in 1966, http://www-pub.iaea.org/MTCD/publications/PDF/Pub146_web.pdf

Others multi-disciplinary meetings have also been held that addressed wide ranging aspects of a resurgent uranium industry.

http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_rawmaterials_tmbestpractices.html

http://www-pub.iaea.org/MTCD/Meetings/cn175_Presentations.asp

About 47 participants from 23 countries presented 27 papers by national representatives, expert consultants and specialists of the IAEA, during five sessions. Dr Greg Sinclair, General Manager Technology Energy Resources of Australia, was Chairman of the meeting. The meeting consensus was that low grade uranium resources, < 0.1%U, will become the future mainstay of uranium supply in view of future high demand scenarios for uranium.

The sessions covered many aspects of low grade ore developments from geology and mineralogy, through development and mining, as well as planning and environmental concerns. Project and feasibility case studies were presented from Europe, Asia, Africa, North and South America and Australia. Large scale open pit mining and the heap leach processing are likely to provide a substantial proportion of future uranium supply.

Building a heap leach pile at Caetite mine, Brazil

A panel discussion amongst the participants was lead by the expert consultants. Predictably, the most interest was shown in the papers related to the new projects and the case studies from 5 continents. It became clear that many projects are close to being economic at the present price of uranium. However, factors limiting possible exploitation were also discussed. The topics of planning, stewardship and good practice were discussed at length in relation to planning and approval of new uranium mines and projects. Sound environmental management, community liaison, effective project delivery, efficient operation, closure strategies, regulatory compliance, personnel training and education will be required to minimize the impact and cost of uranium mining and production, and to secure public acceptance of nuclear energy. For example, ecological, social and water factors, as well as requirements of extended land areas for mining and processing of mostly low grade ores will influence the time frame and community acceptance for new projects. The discussions at the Technical Meeting provided:

- Better understanding by member states of low grade uranium deposits and opportunities;
- Provided information on ore characterization concepts, knowledge and technologies that will potentially assist mining and treatment of low grade uranium resources;
- Described evolving technologies for ore extraction, placement, leaching and disposal for more efficiently and economically exploitation of low grade uranium ore;
- Considered planning, environmental and social issues uranium ore mining, stacking, and leaching including closure of production facilities.

Mature expertise and modern technologies will be needed to ensure an increasing supply of uranium raw materials from low grade resources. The direct treatment of mined and broken uranium ores by heap, dump and in-place leaching is expected to play an increasing role for future uranium production.

Peter Bartsch (P.Bartsch@iaea.org)

New approaches in Waste Processing and Storage: Modular and Mobile Systems

In the course of its journey from the point of generation to final disposal, radioactive waste almost invariably passes through the predisposal steps of processing and storage. Two recent activities on Modular Systems and Mobile Systems focus on new approaches in this area, the goal being to strengthen IAEA efforts to provide guidance on a variety of technical solutions to suit specific needs of Member States in waste processing and storage.

Modular Systems

A modular approach addresses the needs of Member States that do not have nuclear power reactors or fuel cycle facilities, but generate small quantities of low and intermediate level radioactive wastes and disused sealed radioactive sources (DSRS) from applications of nuclear techniques. This approach is a cost-effective and flexible solution that allows easy adjustment to changing needs in terms of capacity and variety of waste streams. An engineering design package has been developed to provide specific guidance on the modular approach for Waste Processing and Storage Facilities (WPSF) that might be best suited to address the predisposal management needs for such situations. The package consists of specification worksheets, design engineering summary, and example technical specifications. The final version will be released as a IAEA Nuclear Energy Series Level 3 report with a CD containing all of the technical details.

The design package is divided into two major parts: processing and storage. The processing package contains a set of pre-designed modules for different treatment and conditioning methods for liquid and solid waste, as well as DSRS. The pre-designed modules are intended to be skid-mounted and could be built and tested in a factory, requiring only final connection of services (e.g. power and water) by the end-user. The design package includes detailed guidance on selection of appropriate technical options for waste processing and design features and requirements including safety and security for the different modules. It also provides general module and interface specifications, module integration, and example of technical specifications for procurement of design and construction services. Though based on the assumption of low throughput requirement, the reference design allows for higher processing capacity to some extent by increasing the frequency or duration of module operation.

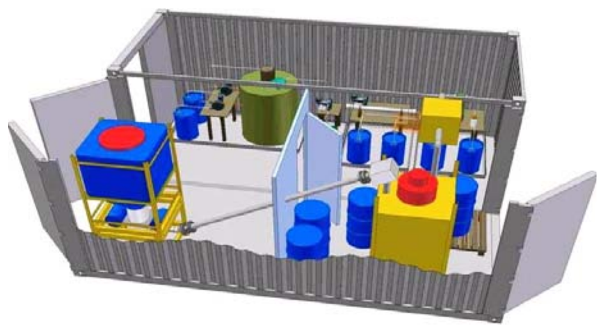


Figure 1. Typical 3-D model view of process modules housed in ISO freight containers

Processing of waste usually results in a package that is suitable for storage and/or disposal. The design package for storage includes a variety of modules starting from a standard ISO shipping container to an aboveground building. The design requirements for the various storage modules have been presented to allow preparation of procurement specifications for detailed design and construction of a storage facility.

In summary, the modular design package should allow end-users to select and combine various waste processing and storage modules together in order to address current needs with a possibility to adjust easily to future expansion.

Successful test launching of this approach has already been demonstrated in TC Regional Workshops held in Europe and Latin America. In addition, these Workshops also focussed on the integration of the design with safety assessment, organization of licensing applications, and operating guidelines.

Mobile Systems

The second new approach in predisposal management focuses on the application of mobile waste processing systems. Such applications are rapidly gaining favour for the pre-treatment, treatment and conditioning of liquid, solid and even gaseous waste streams from nuclear reactors, fuel cycle facilities and nuclear applications. Examples of some technologies more commonly deployed in mobile applications include decontamination, filtration and ion exchange, cementation, polymer fixation of ion exchange resins, and supercompaction. In contrast to fixed on-site or centralized waste processing facilities that require transport of waste, mobile systems offer flexibility in selecting and applying the optimum technology for a specific waste stream by bringing the process to the facility where the waste is generated. This allows equipment sharing amongst multiple sites for processing campaigns that vary in duration from very short periods to several years. Typically the overall cost of mobile systems is less than for fixed systems because of shared use, fewer requirements on infrastructure, and operating personnel. Mobile systems are also well suited for use in decommissioning and in emergencies.

Figure 2. Mobile System for polymer encapsulation of ion exchange resins (Courtesy: SOCODEI, France)

A new IAEA document will include guidance on an iterative approach for determining whether a mobile system is better than a fixed installation, and for selecting mobile waste processing technologies for specific applications and determining feasibility for deployment. All important aspects including local strategy and programme goals, waste stream characteristics, selection and screening of technologies, logistics, interface requirements, and cost are taken into consideration in this guidance. Information on the basic design features of a number of existing mobile systems is provided for helping in the screening process. Additionally, more detailed technical information and data on process, components, interface, material handling are included for two mobile systems as examples. These examples will assist in preparing technical specifications for procurement of detailed design, fabrication and installation of any mobile system.

Zoran Drace (Z.Drace@iaea.org)
Susanta Kumar Samanta (S.K.Samanta@iaea.org)

Highly Enriched Uranium Fuel Repatriation from the Vinca Institute

In 2002, Serbia was the first IAEA Member State to repatriate fresh (unirradiated) high enriched uranium (HEU) fuel to the Russian Federation under the Russian Research Reactor Fuel Return (RRRFR) programme. It was agreed at the time that the IAEA would also assist Serbia in repatriation of spent (irradiated) nuclear fuel (SNF) from the Vinca Institute RA research reactor.

Given the large number of SNF elements (8030) and the anticipated poor condition of the fuel, it was necessary to repackage all of the fuel to ensure safe transport. This resulted in the largest and most complex TC project in IAEA history with an estimated cost of roughly USD 50 million (50M).

The project is currently managed by the Public Company Nuclear Facilities of Serbia (PC NFS) created by the Government in 2009. Recent major milestones by PC NFS include:

- A comprehensive international safety assessment, readiness assessment and FSAR review was successfully completed in Jul'09. This milestone led to FSAR approval and licensing by the Serbian Regulatory Authority (SRA) in Nov'09 for SNF repackaging and transport. (Special thanks to the Slovenian Nuclear Safety Administration for their in-kind contribution of expert support to the SRA which contributed significantly to making this achievement possible.)
- Agreements successfully negotiated between EU and Serbia resulted in EU extrabudgetary contributions of up to EUR 7.73M for repackaging and transport of the SNF, thereby ensuring sufficient funding to return the fuel to Russia.
- Commitments were received from Serbia, Czech Republic, USA, Russia, Nuclear Threat Initiative and IAEA to provide a total of USD 24.96M to fund the Foreign Trade Contract for transport within Russia, SNF reprocessing, and disposition of the resultant high level waste. This led to signing of the Foreign Trade Contract in Sep'09 and opened the door to initiate SNF repackaging.
- More than 200 custom fuel repackaging tools and equipment designed and fabricated by SOSNY R&D Company were delivered to PC NFS throughout 2009; all equipment was assembled, tested and certified for use as of Oct'09; all PC NFS operating personnel completed repackaging training as of Nov'09.
- A custom water chemistry control system (WCCS) was installed and fully operational as of Nov'09. the WCCS minimizes radiation dose rates in working areas of SNF storage pool primarily by controlling specific activity

of Cs-137. (Special thanks to an in-kind contribution by the USDOE-NNSA for the custom design and technical assistance.)

- A campaign to reduce project radiation exposures to As Low As Reasonably Achievable (ALARA) was completed successfully in Nov'09, reducing the overall project exposure budget by a factor of 4.5 as verified by subsequent real-time repackaging exposure data.
- SNF repackaging began early Dec'09; as of the end of Jan'10, 2502 fuel elements were successfully repackaged into new transport canisters.

Looking ahead

- SNF repackaging should complete by May'10.
- The first 12 SNF transport packages will arrive at PC NFS in Jun'10.
- Shipment of SNF to the Russian Federation remains on schedule for 4th Qtr 2010.

John Kelly (J.Kelly@iaea.org)
Sandor Miklos Tozser (S.M.Tozser@iaea.org)

Networking: The Most Efficient Way to unite the Nuclear Community

Since 2001, the IAEA has championed the concept and use of professional networks to advance best practices in radioactive waste management, decommissioning and environmental remediation across the globe. At the present time there are five Networks sponsored by the IAEA and managed from within the Division of Nuclear Fuel Cycle and Waste Technology:

- Geological Disposal (URF Network, established in 2001);
- Decommissioning (IDN, established in 2006);
- Near-Surface Disposal of LLW (DISPONET, established in 2009);
- Environmental Remediation (ENVIRONET, established in 2009); and
- Characterisation of LILW (LABONET, established in 2010).

To date, over 50 organizations from more than 30 Member States are involved in the Networks. Many Network participants generously donate knowledge, resources, time, and effort to share and support Network activities, while others benefit from the acquisition of experience, capabilities and know-how. The universal goal of all the Networks is the promotion of methods and technologies that will enhance the safety and sustainability of radioactive waste management practices and facilities, Networks are the most efficient way to unite our global nuclear communities. Network participants benefit from continuous improvements in communication and knowledge sharing and the provision of opportunities for training, involvement in demonstration projects and the development of novel techniques. To further improve, the five Networks themselves are being moulded into an organic 'Network of Networks' where the use of enhanced communication channels and social networking tools will be exploited to facilitate effective and rapid direct linkages between Network participants.

Since 2001, in excess of 300 people have benefited from WTS Network training events. Feedback from students and parent organizations acknowledges that the Networks serve a valuable purpose in this regard, but the current methods used to deliver our training have some limitations. In particular there are four issues to be improved concerning the provision of training:

- More should be done to ensure the suitability of candidates for face-to-face training.
- Training courses are currently almost exclusively based on face-to-face events (maximum 20 people).
- Network training courses currently offered cover a relatively limited number of specialist topics and more could be done to cater to wider needs.
- 'Newcomer' countries (i.e. those Member States that are seriously considering or have made a decision to proceed with nuclear power generation) require significant support, but currently this area is under-represented in available training opportunities.

Therefore, the range of training material to be provided by the IAEA will need to be significantly increased, and it needs to be accessible to a much larger audience of trainees than is currently possible. Additionally, better screening of applicants for the limited face-to-face training opportunities will maximize cost-effectiveness, but still does not improve the accessibility to more participants.

A critical appraisal of the current functioning of the Networks suggests that communication links are mainly directed outward from the IAEA or received inward by the IAEA. There is little tangible evidence of direct and multiple interactions between the participants themselves. Of course, such interactions do occur, but the question is "would these particular interactions have occurred anyway without the Network"?

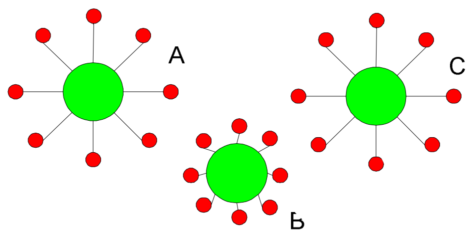


Figure 1. Conceptualisation of the individual networks .

Figure 1 shows conceptualisation of the individual networks as they currently operate (hub & spoke model with the IAEA at the centre). Participants are generally poorly connected to each other (a). Then every year the participants come together with the IAEA at an annual meeting (b), only to disperse again afterwards (c). It is believed that connections directly between participants as a result of the Networks are not as strong as they could be.

In order to address the above issues, WTS is extending the Network concept from the current IAEA-centric, low-tech and sector-based paradigm to one that is much more interconnected, inclusive and holistic, which will maximize the coverage of important topics, especially at interfaces between disciplines, and should allow for more efficient delivery of training.

The proper application of internet-based tools can expedite increased connectivity, enhance communications, and also provide for much more effective delivery of education and training.

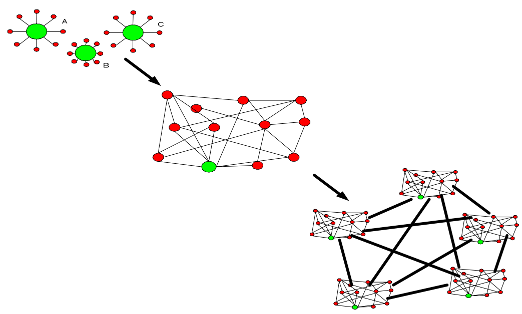


Figure 2. Development of networks from the current hub & spoke model towards a true network of multiple connections that are then linked within a 'network of networks', with communications facilitated through the use of internet-based platforms and electronic media.

An Internet Portal is currently being developed, to act as a gateway for interactions between individuals and organizations involved in all aspects of radioactive waste management. The Portal being developed with this multiple functionality has been given the acronym CONNECT, which stands for 'Connecting the Network of Networks for Enhanced Communications and Training'. The development is being funded jointly by the IAEA and the European Community, with in-kind support from some of the larger RWM organizations.

CONNECT will allow users to communicate directly with others in near real-time, support technical forums and current events blogs, host technical resources, and deliver web-based training modules and topical video clips. In terms of expected outcomes, CONNECT will permit and encourage enhanced collaboration and information exchange in the radioactive waste management field throughout the world. A wide range of training resources will be created for hosting within CONNECT and these will be freely available to all radioactive waste management practitioners. As a result, IAEA expects an increase in the adoption of best international practices, enhanced skills and capabilities within organizations, and increased stakeholder confidence in waste management.

Paul Degnan (P.Degnan@iaea.org)
Paul Dinner (P.Dinner@iaea.org)
John Kinker (J.Kinker@iaea.org)

Practical Training in Decommissioning: A Winning Formula

A special IAEA 'hands on' version of the famous Argonne National Laboratory (ANL) Decommissioning Course at Argonne was held in April. In Chicago, Mr. Mark Hannan (IAEA) worked with Mr. Larry Boing (ANL) and his team from ANL to build a week of practical exercises into the training course. The event achieved a high degree of hands-on involvement of the participants and the result of this 2-week long intensive course has confirmed that getting our participants into the field with mock-ups and simulations is an essential step to better equip them for contributing to the work of their organizations.

According to Mr. Boing, there were attendees with decommissioning experience who said that this was a very good next step for them and a nice first step for the newcomers. The Member States representatives identified their current issues and problems, providing a great opportunity to address them in future training events. As this event was considered a 'prototype', the Argonne team have been working on improvements for the course planned for next year. "At this point, it is believed that we should broaden it more, participants-wise, and include other Member States," Mr. Boing said. He also mentioned that a 'Detailed Site Characterization Day' or a 'Sites and Material Clearance Day' may be considered to compose part of the program for next time.

This year's ANL course consisted of a merging of core decommissioning lectures with field demos and practical application demonstration and exercises. Feedback on this year's participants was that they were an outstanding group of professionals who posed excellent questions, were attentive to details, and were enthusiastic participants in all of the exercises, according to Mr. Boing. There is another benefit to this focus as well – the quality of nominees to IDN events is definitely improving: we are seeing more motivated, younger, multi-lingual candidates who are well-prepared and who are directly engaged in decommissioning in their home countries. They can bring the message home (literally and figuratively) that this form of training works.

Paul Dinner (P.Dinner@iaea.org)

Andressa Junger (A.Junger@iaea.org)

Figure 1. Dressing Out

Figure 2. Bagging Contaminated Tools Before Egress

New Training for Low Level Waste Disposal

The Low Level Waste Disposal Network (DISPONET) has launched a new systematic training programme aimed at the development of a disposal facility for very low level and low level radioactive waste (VLLW and LLW, respectively). Training courses will be organized for each region: Asia, Latin America, Africa, and Europe. The initial set of courses delivers messages at the general level: participants are introduced to the waste disposal basis, organizing the project, the role of design, siting procedure elements and relevant safety aspects, and instructed on how to identify and manage stakeholders. They are also expected to present developments of their own national waste management programmes and, in this way, seek similarities allowing them to establish direct links for sharing information and experience. In practical exercises, such as outlining repository development or public communication programmes, they test how effectively they absorbed the course material. A visit to a waste disposal facility is an important part of each course as it allows trainees to compare theoretical instructions with real situations.

The February training course focused on the Middle East and Asia countries: hosted by the Bhabha Atomic Research Centre (BARC) in Mumbai, India, it introduced twenty foreign and five local attendees to the fundamentals of LLW disposal. The five-day event included lectures prepared by BARC staff members and IAEA specialists, and a site visit to the waste management facilities of nearby Tarapur Nuclear Power Plant.

The following course, organized by ENRESA, Spain, was held in March in Cordoba, and included a site visit to the El Cabril disposal facilities for VLLW and LLW. Fifteen participants coming from seven Latin America countries were taught in Spanish by ENRESA staff members and an IAEA representative: this allowed for training of specialists for whom language had been a barrier to joining earlier events organized by the IAEA.

The participation of trainees in both events was financially supported by regional and national Technical Cooperation programmes. Teaching by host organization specialists and site visits were arranged – in agreement with DISPONET principles – as an in-kind contribution that allowed the use of savings for increasing the number of participants.

Two more courses on LLW disposal principles will be performed in March 2011 in South Africa and Spain (for African and European countries, respectively). In the same year, a new level of courses will be initiated aimed at specific repository development matters, such as dealing with the public, running siting projects, long term safety, and operational experience.

VLLW Disposal cell at El Cabril, Spain

Very low and low level waste disposal facility El Cabril, Spain

Lumir Nachmilner (L.Nachmilner@iaea.org)

Elimination of the Nuclear Legacy in the Far East of Russia by International Partners: Achievements and Plans

CEG Members discussed joint international efforts in elimination of the Cold War nuclear legacy in the Far East of Russia at the workshop held in late May 2010 in Vladivostok. This legacy consists of 80 decommissioned nuclear submarines and ships, submarine spent nuclear fuel (SNF), various types of radioactive waste (RW) and contaminated areas earlier used by the former Soviet Navy. The international programmes for addressing the nuclear legacy in the Far East of Russia have reached the highest point of development and implementation to date. Many pressing legacy issues have been resolved, and there is a clear vision of what needs to be done in future. Most of these programmes stem from the Global Partnership initiative (2002-2012), and some of these major successes are described in this article.

The nuclear submarine dismantlement programme in Far East Russia is nearing its successful completion with strong international assistance. Of 78 decommissioned nuclear submarines, 71 have been defuelled and dismantled; 52 by Russia, 13 with US funding, 6 with Japanese funding, and 3 are currently being dismantled under the Canadian programme. Australia, New Zealand, and the Republic of Korea have also contributed to joint efforts via the Japanese and Canadian programmes. The donors have also assisted in building new infrastructure and facilities for SNF unloading and submarine dismantlement. Canada funded removal of decommissioned submarines by a heavy lift vessel from Kamchatka to the Zvezda shipyard (over 2 500 km distance) for dismantlement (see photos).

The challenge ahead is isolation of two submarines with SNF on board damaged by nuclear accidents. The isolation facility is currently being built and will be ready to receive the two submarines by 2011 and 2012, respectively. The dismantlement of 11 nuclear surface ships and service vessels has only started and will be carried out from 2010 to 2015.

In 2009, Russia resumed safe removal of legacy SNF from the region to the Mayak Plant for reprocessing, having upgraded the transport infrastructure with the assistance of Canada. All undamaged legacy SNF is to be removed from the region by end of 2012. Damaged SNF could be unloaded from the storage facility and removed in 2015 when specific unloading technologies which are currently being developed are adopted and a special hot cell for damaged SNF canisters is created with the French assistance at Mayak.

For further nuclear waste treatment a regional centre for RW management is to be created on the basis of DalRAO (a Rosatom Corporation company for legacy RW management in the Far East). All RW in the region are to be collected from various sites and consolidated in the Regional Centre, which will be responsible for waste treatment, long-term storage and disposal. All RW and submarine reactors located at the Kamchatka peninsula will be removed from to the centre and the area will be remediated.

The biggest challenge will be to place 76 submarine reactor compartments (each with two de-fuelled reactors on board, left over from submarine dismantlement) into a long term storage facility which is currently being built by DalRAO. Japan and Germany are supplying lifting and transport equipment to the facility, which should be ready to receive first reactor units by the end of 2011.

RW at many temporary storage facilities needs to be certified and repacked. The centre is yet to acquire full scale capabilities for liquid and solid RW treatment and long term storage. Japan has already provided a facility for reprocessing of low level RW that is now instrumental in submarine dismantlement programme. Now the priority of DalRAO is to complete the construction of a large reprocessing facility for liquid RW with high salt content and a long term storage facility for low and medium RW.

Disposal of very low level waste is planned to be done at the centre. A site for underground disposal of low and intermediate level waste has been identified (about 20 km from the centre). However many decisions on this facility are yet to be taken. High level waste and long lived waste will be disposed at the planned deep geological repository in Siberia (near Krasnoyarsk).

Almost all of the 121 radioisotope thermoelectric generators (RTGs) in the Pacific have been removed from remote areas and secured at DalRAO with US and Canadian assistance, which also included provision of a temporary storage facility. The RTGs are to be removed for disassembling and long term storage. A remaining 75 RTGs in Chukotka will be recovered in 2011-12 by joint Russian and the US efforts.

Transportation of two decommissioned nuclear submarines to the distance of 2500 km for dismantlement at a shipyard

Transport infrastructure has been modernized to start safe removal of SNF from the Far East

Oleg Goroshko (O.Goroshko@iaea.org)

Closing in on Sustainability

The current, once-through fuel cycle utilizes about 0.5% of our uranium resources to generate energy, leaving the rest as either depleted uranium or high-level waste. The use of fast breeder reactors in a closed nuclear fuel cycle has the potential to make the utilization of our uranium resources one-hundred times more efficient, while reducing the amount of high-level waste produced. This would mark a huge step towards the sustainability of the nuclear fuel cycle.

Fast reactor R&D programs were started in a number of countries in the 1940s and 1950s. Around 1980, experimental reactors were operating in many countries, such as France, Germany, Japan, UK, USA and Russia (then the USSR). However, at the time, there was no compelling need for fast reactors and most development programs were scaled back, or cancelled.

Today, however, with renewed interest in developing long-term, sustainable nuclear energy solutions, interest and activity in the development of fast reactors is again on the rise.

This year has been a very exciting one in the move towards closed nuclear fuel cycles. On the morning of May 6 2010, the Japanese fast breeder reactor Monju restarted for the first time since 1995. This summer, the Chinese Experimental Fast Reactor (CEFR) achieved its first criticality on 21 July. The Chinese Government plans to follow this milestone with construction of prototype fast power reactors beginning next summer.

Many other countries also have ambitious plans to close their own fuel cycles. Russia, for example, is vigorously pursuing the development and deployment of an evolutionary line of fast reactor designs beginning around 2013. Prototype fast reactors should be operational in India, France and Japan around 2011, 2020 and 2025, respectively.

The IAEA has been working hard to encourage the development of the materials, fuels and fuel cycles necessary for the large-scale closure of the nuclear fuel cycle.

Key to the development of fast reactors will be the availability of materials which can withstand the harsh radiation and high temperature environments typical of fast-neutron systems. These materials are the topics of the Coordinated Research Projects (CRP) ‘Cladding and Wrapper Materials for Sodium-Cooled Fast Reactor Fuel Assemblies’ and ‘Benchmarking of Structural Materials Pre-Selected for Advanced Nuclear Reactors’. Improvements in our ability to simulate and model radiation damage would greatly facilitate the development of these materials and are examined in the CRP ‘SMORE’ (Accelerator Simulation and Theoretical Modelling of Radiation Effects).

A recent Technical Meeting on ‘Manufacturing Methods for Advanced Nuclear Fuels’ examined the fabrication of a number of reactor fuel types, including fuels for fast reactors.

Advanced separation technologies will drive future closed fuel cycles and are an area where favourable developments could provide enormous improvements in the economics of the fuel cycle. An IAEA CRP studying process losses recently completed a technical document entitled ‘Assessment of partitioning processes for Transmutation of Actinides’ (IAEA-TECDOC-1648).

The IAEA also participates, as a member of their End User Group, in the European Framework 7 Program ‘ACSEPT’ (Actinide Recycling by Separation and Transmutation), in which advanced separation technologies are being developed and evaluated. This participation included support for the recent ACSEPT International Workshop, where the current state-of-the-art in separation technologies was passed on from top experts to the next generation of practitioners.

Dr C. Caravaca delivers a lecture at the First ACSEPT International Workshop, Lisbon.

Additional activities in all areas of support for the advancement of closed fuel cycles are under way or under development. We will continue our efforts toward developing future, sustainable nuclear fuel cycles.

For further information, please visit:

http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_home.html

Gary Dyck (G.Dyck@iaea.org)

New Staff

Charles Morris recently taken up duties in the Research Reactor Section as a nuclear engineer. His main areas of responsibility will be related to the modernization, and innovative developments for research reactors. He joined the IAEA from ANSTO where he was involved with the OPAL reactor form its inception. Previously at ANSTO he was an Instrumentation and Control (I&C) engineering group leader, and Duty Officer at the HIFAR reactor, starting work there in 1994. Previously he was employed by the Wolf Creek Nuclear Operating Corp for 16 years, and was in charge of all aspects of PWR, I&C design. Prior to Wolf Creek he was employed at Bruce NGSA for 3 years after graduating from McMaster University in Hamilton Ontario.

Sandor Tozser recently joined the Research Reactor Group as a Cost-Free Expert from Hungary. He works on matters related to the Global Treat Redaction Initiative (GTRI) specifically on the Russian Research Reactor Fuel Return Programme and research reactor core conversion activities that convert research reactors fuel from HEU to LEU fuel. Mr. Tozser joins us from the Atomic Energy Research Institute, Budapest, Hungary. He was the manager of the Budapest Research Reactor since 2001 until his departure for the IAEA. As a reactor manager he had complete responsibility for safe rector operation. He was responsible for the site preparation and SNF characterization for spent HEU fuel return from Budapest to the Russian Federation in 2008. He is an electrical engineer graduated on the Technical University of Budapest in I&C faculty. He completed a M.Sc. degree in 1978.

Ali Carrigan joined the Research Reactor Section in July 2010 as an information analyst. Previously, she worked in the Information Collection and Analysis Section in the Department of Safeguards, and spent her formative years interning at Lawrence Livermore National Laboratory in California. Ali earned her PhD from the War Studies Department at King's College London. Her research focused on policy responses to the spread of nuclear knowledge, and has been published in *Physics Today*

Kevin Alldred is a Physicist, MBA and enthusiastic internationalist. He started his scientific career in the U.K. designing radiometric instrumentation systems before shifting gears to project manage the flowsheet development for the U.K. MOX fuel fabrication pilot plant. He helped to structure BNFL's international LWR fuel business, the relocated to the USA to successfully launch a U.S. isotopes trading business for the nuclear fuel trading company, NUKEM Inc., and to support its various uranium projects in Central Asia and elsewhere. Kevin set up International Nuclear Enterprise Group, LLC in 2001, providing consulting resources in the non-proliferation, nuclear fuel cycle, nuclear science and research reactor sectors. He joined the IAEA's Research Reactor team (NEFW-RRS) in February 2010.

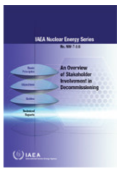
Recent Publications

IAEA Nuclear Energy Series No. NF-T-1.2
Best Practice in Environmental Management of Uranium Mining (2010)

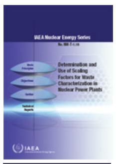
IAEA Nuclear Energy Series No. NW-T-1.21
Technological Implications of International Safeguards for Geological Disposal of Spent Fuel and Radioactive Waste (2010)

IAEA Nuclear Energy Series No. NW-T-1.20
Disposal Approaches for Long-Lived Low and Intermediate Level Radioactive Waste (2010)

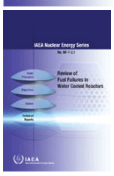
IAEA Nuclear Energy Series No. NF-T-4.6
Status of Minor Actinide Fuel Development (2010)



IAEA Nuclear Energy Series No. NW-T-2.5
An Overview of Stakeholder Involvement in Decommissioning (2009)



IAEA Nuclear Energy Series No. NW-T-1.18
Determination and Use of Scaling Factors for Waste Characterization in Nuclear Power Plants (2009)

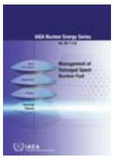


IAEA Nuclear Energy Series No. NF-T-2.1
Review of Fuel Failures in Water Cooled Reactors (2010) **NEW!**

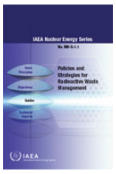
IAEA-CN173
Proceedings of International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators, 4–8 May 2009, Vienna (2010)**NEW!**

IAEA Nuclear Energy Series No. NF-T-5.2
Good Practices for Qualification of High Density Low Enriched Uranium Research Reactor Fuels (2009)

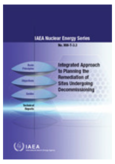
IAEA Nuclear Energy Series No. NF-T-1.1
Establishment of Uranium Mining and Processing Operations in the Context of Sustainable Development (2009)



IAEA Nuclear Energy Series No. NF-T-3.6
Management of Damaged Spent Nuclear Fuel (2009)



IAEA Nuclear Energy Series No. NW-G-1.1
Policies and Strategies for Radioactive Waste Management (2009)



IAEA Nuclear Energy Series No. NW-T-3.3
Integrated Approach to Planning the Remediation of Sites Undergoing Decommissioning (2009)

IAEA Nuclear Energy Series No. NF-T-4.4
Use of Reprocessed Uranium: Challenges and Options (2010)

IAEA Nuclear Energy Series No. NF-T-3.5
Costing of Spent Nuclear Fuel Storage (2009)

IAEA-TECDOC-1648
Assessment of Partitioning Processes for Transmutation of Actinides (2010) **NEW!**

IAEA-TECDOC-1637
Corrosion of Research Reactor Aluminium Clad Spent Fuel in Water (2010)

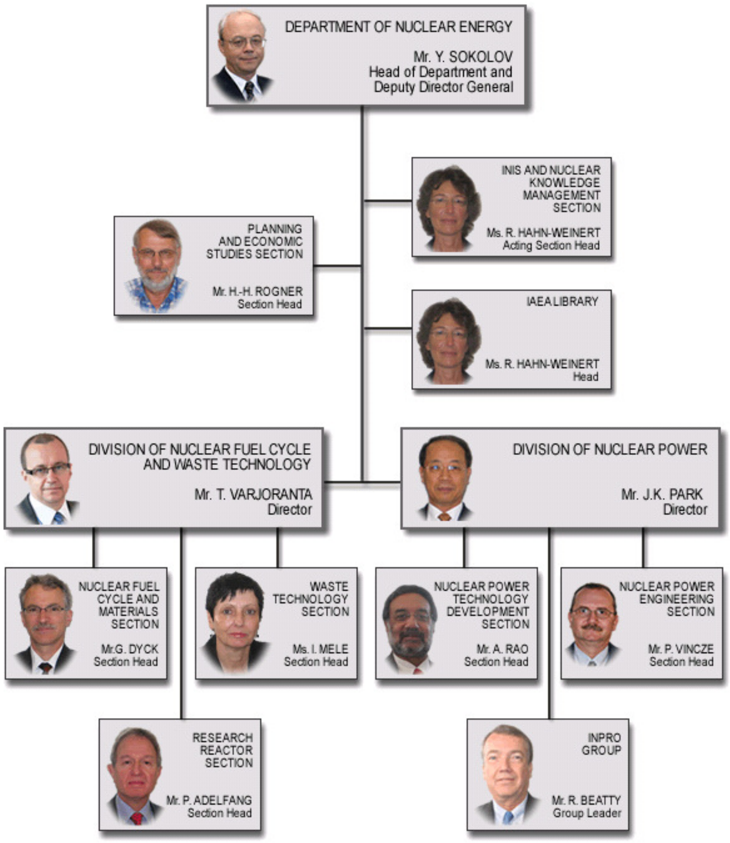
IAEA-TECDOC-1632
Experience of Shipping Russian-origin Research reactor Spent Fuel to the Russian Federation (2009)

Upcoming Meetings in 2010

Date	Title	Place	Contact
6-9 Sept	TM on High Temperature Gas-cooled Reactor Fuel and Fuel Cycle	Vienna Austria	U.Basak@iaea.org
13-17 Sept	TM on Conversion of Miniature Neutron Source Research Reactor (MNSR) to Low Enriched Uranium (LEU), Fuel Design and Spent Fuel Shipment	Beijing China	R.Sollychin@iaea.org
28-30 Sept	Plenary Meeting of the Centres of Excellence in Low Level Waste Disposal (DISPONET)	Vienna Austria	L.Nachmilner@iaea.org
4-8 Oct	TM on Processing of Waste from Innovative Types of Reactors and Fuel Cycles	Vienna Austria	Z.Drace@iaea.org
18-22 Oct	Third RCM on Behaviour of Cementitious Materials in Long Term Storage and Disposal of Radioactive Waste	Kalpakkam India	Z.Drace@iaea.org
18-22 Oct	TM on Management and Disposal of Naturally Occurring Radioactive Materials (NORM) Waste	Vienna Austria	H.Monken-Fernandes@iaea.org
28-29 Oct	TR/Workshop on Environmental Remediation	Moscow Russian Fed.	H.Monken-Fernandes@iaea.org
9-11 Nov	Annual Forum for Regulators and Operators in the Field of Decommissioning: the International Decommissioning Network (IDN) and other major Decommissioning Initiatives	Vienna Austria	P.Dinner@iaea.org
9-12 Nov	TM on Developing Techniques for Small Scale Indigenous Molybdenum-99 Production using Low Enriched Uranium (LEU) Fission or Neutron Activation	Santiago Chile	E.Bradley@iaea.org
22-24 Nov	TM on Water Chemistry and Clad Corrosion/Deposition including Fuel Failures	Kiev Ukraine	J.Killeen@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

Fuel Cycle and Waste Newsletter
Vol. 6, No. 2, August 2010

The Nuclear Fuel Cycle and Waste Technology Newsletter is prepared quarterly by the Division of Nuclear Fuel Cycle and Waste Technology, Department of Nuclear Energy.

Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Printed by the IAEA in Austria, August 2010.

10-35801