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Fuel Cycle and Waste Newsletter

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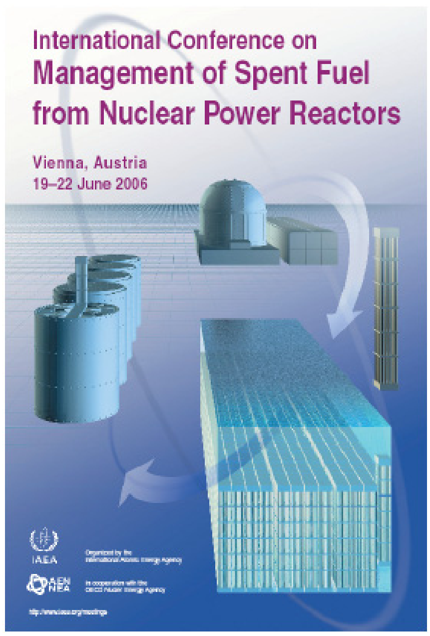
International Conference on Management of Spent Fuel from Nuclear Power Reactors (CN-144)



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 19 to 22 June 2006 in Vienna. The conference was attended by 150 participants and observers from 36 countries and 4 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. Dr. Jacques Bouchard, CEA, served as Conference President and also chaired the 19 June session entitled *"Spent Fuel Management – Evolving International Scene"* that showcased these emerging initiatives.

Mr. Larry Brown represented the US Secretary of Energy by describing progress in establishing the US Global Nuclear Energy Initiative. Mr. Anatoly Zrodnikov, IPPE Director General, followed with a presentation on the Russian President's Initiative focused on aspects relevant to spent fuel management. A subsequent presentation on French choices for the backend of the fuel cycle by Florence Fouquet, head of nuclear energy for the French Industry Ministry, fit well in the session on the evolving international scene, given their national dialogue and proposed legislation this year relevant to spent fuel management. Dr. S.K. Jain, Chairman and Managing Director, Nuclear Power Corporation of India, Limited, addressed evolving policies in expanding economies and represented one of a number of Member States anticipating significant growth in civilian nuclear power capacity. Following IAEA and NEA presentations on international perspectives, Mr. Bruno Pellaud highlighted multi-national approaches relevant to spent fuel management by drawing on the results of the 2005 Expert Group report to the IAEA Director General. Safety-related sessions convened on 20 June, and included addresses by Andre-Claude Lacoste, head of the French regulatory authority, and others as well as panel discussions. Technology-related sessions were the focus on 21 June, with presentations moving from facilities to containers to the properties and behaviour of the spent fuel itself, and also followed by panel discussions. The conference concluded on 22 June with a look to the future in spent fuel management, including a keynote presentation and summaries by the session chairs and the Conference President.

As reflected in the summaries, conference participants agreed that the most important conclusions and findings for the future include the following:

- Rising expectations for nuclear energy will continue to motivate new initiatives addressing the back end of the fuel cycle, including recycling options;
- Storage remains an interim solution, and all fuel cycle options require geological disposal sooner or later;
- Current wet and dry technologies for spent fuel storage are mature and safe, but as storage durations extend and specifications and designs evolve, continued R&D will be needed particularly for behaviour of fuels with higher burnups and new cladding materials;
- Further work is required to develop safety standards regarding spent fuel management, including not only storage but also recycling options;
- Further progress on reporting to the Joint Convention relevant to spent fuel was encouraged;
- Multilateral approaches will continue to be of interest given the potential benefits described by the 2005 DG Expert Group report;
- The evolving international scene has made spent fuel management one of the more important factors influencing the future of nuclear energy.

Message from the Director

Colleagues,

Over the last few years there has been a contiuously increasing interest in the issues connected to the nuclear fuel cycle. After more than 10 years of low and stable uranium prices, the prices on the spot market have rapidly increased. The latest published spot market price (~ 47 US$/lb U_3O_8) is about 7 times the historic low registered at the beginning of 2001, reflecting the inbalance between primary supply and demand and the expected reduction in stockpiles and other secondary supplies. This has lead to increased activities on exploration and mining developments.

In many countries we see signs of rising expectations for the use of nuclear energy. This puts focus on the long term uranium supply and the long term sustainability of nuclear power. The interest for closed fuel cycle activities has therefore increased substantially also in countries that until recently did not consider recycling. Within the Generation IV International Forum four of the six concepts studied are fast or epithermal reactors with a closed fuel cycle. Recent initiatives like the Russian proposal for an International Fuel Cycle Centre and the US proposal for a Global Nuclear Energy Partnership also involves development work on treatment and recycling of fuel. But recycling also raises issues of proliferation and the recent initiatives also have components addressing this.

This issue of the Fuel Cycle and Waste Newsletter is entirely devoted to the work performed within the Nuclear Fuel Cycle and Materials Section of our Division. It covers a very broad spectrum of activities from uranium and thorium exploration, through the use of nuclear fuel in reactors to the management of the spent fuel and its subsequent recycling. I hope that you will find interesting and stimulating reading that will encourage further contacts with members of the IAEA staff.

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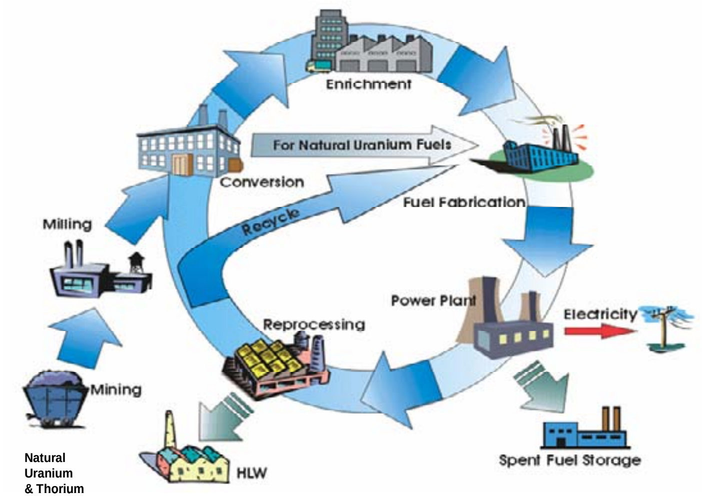
Nuclear Fuel Cycle & Materials Activities



"For nuclear energy to be sustainable as a global source of emission-free energy, the reactor fuel cycle must also remain sustainable" – DG-IAEA.

Nuclear fuel cycle activities go hand in hand with nuclear reactor technology and encompass various processes and technologies related to mining and milling of uranium and thorium ores, conversion to pure process intermediates, enrichment of uranium, fabrication of fuels and their utilization in reactors, storage of spent fuel, reprocessing for recovery and recycling of plutonium and other actinides, and conditioning high level radioactive waste (HLW) for final disposal in repositories. In open once-through fuel cycles, the spent fuel is not reprocessed but after long storage, encapsulated and disposed in repositories.

The nuclear fuel cycle programme in the Agency facilitates and provides support to interested Member States, in establishing, maintaining and strengthening (through innovation) the nuclear fuel cycle and spent fuel management activities for power reactors and research reactors. The programmes aim at: promoting information exchange through organization of conferences, technical meetings and publication of technical documents; and, conducting Coordinated Research Programmes (CRP) and providing Technical Co-operation (TC) under the following subprogrammes:

- **Uranium and thorium resources:** their exploration, mining, production and environmental issues; preparation of updates on uranium resources, production, and demand known as the Red Book , published jointly with OECD Nuclear Energy Agency (NEA), once in two years; and maintaining databases on world uranium deposits (UDEPO) and nuclear fuel cycle facilities (NFCIS).
- **Power reactor fuel engineering**: covering fuel design, manufacturing, performance modelling and effects of water chemistry; a database on post – irradiation examination (PIE) is maintained.
- **Management of spent fuel from power reactors**: covering dry and wet storage of spent fuel, design of storage casks, burn-up credit, and treatment, reprocessing and recycling options of spent fuel.
- **Advanced and innovative nuclear fuels & fuel cycles**: for fast reactors, high temperature gas cooled reactors and other innovative reactors, proliferation resistance of fuel cycle, management of fissile and fertile materials for peaceful applications; minor actinide data base (MADB) and fuel cycle simulation system (VISTA).
- **Research reactors**: fuels and fuel cycle, conversion of HEU to LEU cores and targets, issues related to modernization and utilization of research reactors for development of advanced fuels and reactor structural materials.

Uranium and thorium resources

In the last three years there have been rising expectations for the increased use of nuclear power worldwide. This has led to increased demand for uranium and dramatic increase in uranium price, which has paved the way for revival of uranium raw material industry after a slump of nearly two decades. Presently, the annual reactor demand for natural uranium is approximately 67 000 tonnes to fuel some 440 operating nuclear power reactors with total installed capacity of ~370 GW(e). Only ~60% of the reactor demand is met by primary uranium supply from the mines, with the remainder being met by secondary supplies. The identified conventional uranium resources (4.74 million tonnes) and the undiscovered resources (7.1 million tonnes) recoverable at <130US$/kg U and the additional additional 22 million tonnes of unconventional uranium in rock phosphate are adequate to meet the projected future requirements. However, the gap between uranium in-ground and uranium yellow cake in the market has to be narrowed.

Fortunately, the strong market and sustained high prices during the last two years have enhanced investment in uranium exploration, mining and production. Airborne and ground exploration based on new geophysical techniques are being utilised to discover deep and more obscure uranium deposits. New mines and mills are being opened and major producers have increased their production. There has been major expansion in *in-situ* leach (ISL) mining. The Agency has planned a number of technical meetings and workshops and has initiated new training and Technical Cooperation programmes in uranium exploration, mining, milling and environmental protection.

Power reactor fuel engineering

The present generation of nuclear power reactors in the world is mostly thermal reactors. Light water reactors (LWRs) are most common, followed by the pressurized heavy water reactors (PHWRs). The trend in these reactors, particularly in LWRs, is increasing fuel burnup, with higher ratings and longer dwell time. The CRP on Fuel Modelling at Extended Burnup (FUMEX-2) enhanced the capability of fuel codes used in Member States to accurately predict fuel performance at high burnups, both for normal operation and under transient conditions.

Likewise, the CRP on Data Processing Technologies and Diagnostics for Water Chemistry Control in Nuclear Power Plants (DAWAC), provided a better understanding of water chemistry control for efficient and safe plant operation with increased fuel burnup, longer fuel residence times and fewer failures.

Spent fuel management

Long term storage of spent fuel from power reactors is becoming a reality in most Member States. The experience with the safe storage of spent fuels for more than three decades in several Member States, together with continuing technical advances have given the confidence to store spent fuel for as long as is required for a country to decide on recycling or ultimate disposal. An estimated 200 000 t HM of spent fuel are in storage facilities around the world. Capacity must be provided for an additional 8 000 t HM per year for the immediate future. An accelerated global expansion of nuclear power will add to that requirement.

The Agency plays a central role in building up the technical knowledge base for the long term storage of power reactor spent fuel. This includes a series of CRPs on Spent Fuel Performance Assessment and Research (SPAR). Other important meetings convened by the Agency within the past year have addressed advances in applications of burnup credit to enhance spent fuel transport, storage, reprocessing and disposition, and the handling of damaged fuel. The concept of regional spent fuel storage is attractive, technically feasible, and economically viable for arranging extended interim storage of spent fuel in countries with limited nuclear power programmes. However, political and public acceptance issues are real and difficult to resolve.

Advanced fuels and fuel cycles

Several recent studies have provided Member States with information on the status and viable management options for peaceful utilization of high enriched uranium (HEU), reprocessed uranium (Rep U), plutonium and minor actinides (MA), and the assurance ‘proliferation resistance’.

Conventional and advanced fuels for liquid metal cooled fast reactor (LMFR) fuels, partitioning and transmutation of actinides in ‘closed’ fuel cycles are being analysed with Member States for efficient use of uranium and thorium raw materials, recycling of plutonium and burning MA. Thus, the volume, decay heat and radiotoxicity of high activity waste for geological disposal would be minimized significantly. The status of conventional fuel for LMFR, namely, mixed uranium-plutonium oxide, and advanced LMFR Fuels, namely mixed uranium-plutonium monocarbide, mononitride and U-Pu-Zr and their reprocessing by aqueous - and pyro - routes are being updated and compiled.

As part of advanced and innovative fuel cycle activities, studies on multilayer coated fuel particles for high temperature gas cooled reactors (HTGR), HTGR fuel cycle, and thorium utilization in thermal and fast reactors are underway. Different options are being studied to introduce "intrinsic" proliferation resistance in the fuel cycle.

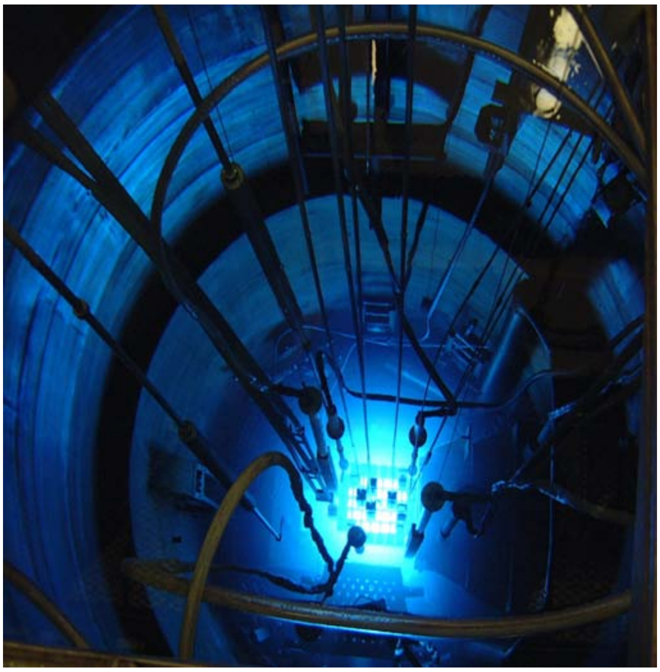
The fuel cycle activities are being tuned to meet the technical and political challenges of programmes such as INPRO, Generation IV International Forum (GIF), the Agency's Multilateral Approaches to Nuclear Fuel Cycle (MNA), the Global Nuclear Energy Partnership (GNEP) proposal of US and Global Nuclear Infrastructure-International Fuel Centre (GNI-IFC) concept of the Russian Federation. The common features of MNA, GNEP and GNI-IFC are assurance of fuel supply and proliferation resistance.

Research reactors

For over 60 years research reactors (RRs) have been used for a variety of purposes such as the production of isotopes for medicine and industry, non-destructive testing, modification of materials, research in physics, biology and materials science, support of nuclear power programmes and development of nuclear science and technology in general.

The Agency's competence in the area of RRs has been continuously built since its foundation in 1957. The support of the Agency was of fundamental importance for building of new RRs of research reactors until 1995, when the number of developing countries with at least one research reactor peaked at 41. At present many RRs are facing aging problems and increasing pressure to improve utilization and to develop appropriate strategic plans, in order to meet commercial and scientific goals and improve sustainability. Besides, RRs have to respond to international efforts that seek minimization of the use of HEU and are urged to convert to LEU and return spent and fresh HEU to the country of origin.

To address these challenges, the Agency initiated in 2005 a comprehensive number of new activities in support of RR modernization, refurbishment, non-proliferation, RR core conversion from HEU to LEU and fuel cycle issues.



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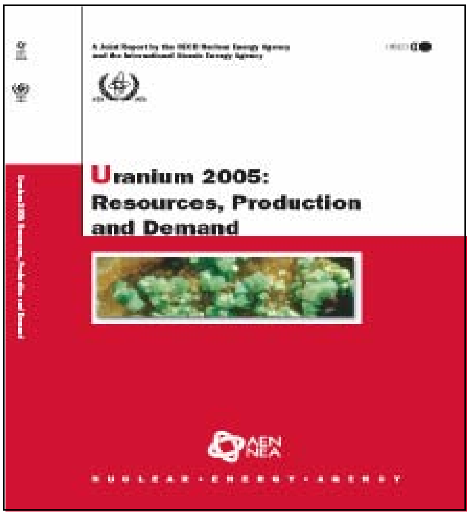
21st Edition of Red Book "Uranium 2005: Resources, Production and Demand"

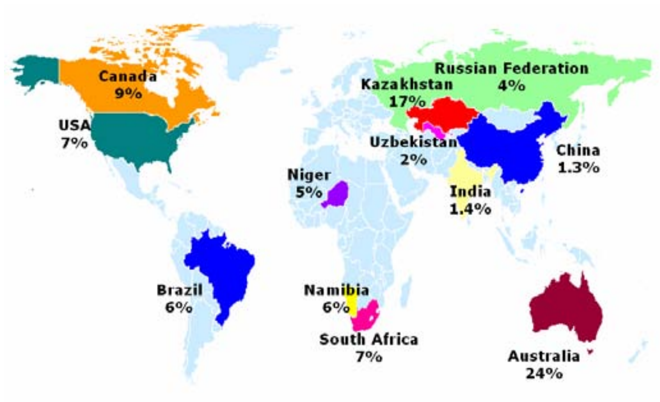


The 21st edition of the Red Book, entitled, 'Uranium 2005: Resources, Production and Demand', jointly prepared by IAEA and OECD/Nuclear Energy Agency (NEA), was officially released on 1 June 2006 in a press briefing function at the OECD Headquarters in Paris.

The Red Book is a recognized world reference on uranium, which is used by Member States producing uranium and/or having nuclear power programme for their planning and policy making. Since the mid 1960s, the IAEA and OECD/NEA have been preparing periodic updates (currently every two years on) of the Red Book with the cooperation of their Member States and countries. The document provides a statistical profile of the world uranium industry in the areas of exploration, resources estimates, production and reactor-related requirements. The 21st edition reflects information current as of 1 January 2005 received from the governments of 43 countries (18 OECD and 25 non-OECD countries). It provides substantial new information from all the major uranium producers in the world and gives a projection of nuclear generating capacity and reactor-related uranium requirements through 2025 and discusses long term supply and demand issues related to uranium raw material.

Cost category	Identified Resources		Prognosticated Resources	Speculative Resources
	Reasonably Assured Resources (RAR)	Inferred Resources		
Additional resources with no cost estimate				3.0 Mt U
Total < $ 130/kg U*	3.3 Mt U	1.4 Mt U	2.5 Mt U	4.6 MtU
$ 80-130/kg U	0.7 Mt U	0.3 Mt U		
$ 40-80/kg U	0.7 Mt U	0.4 Mt U		
< $ 40/kg U	1.9 Mt U	0.8 Mt U		

* Totals may not add due to rounding.



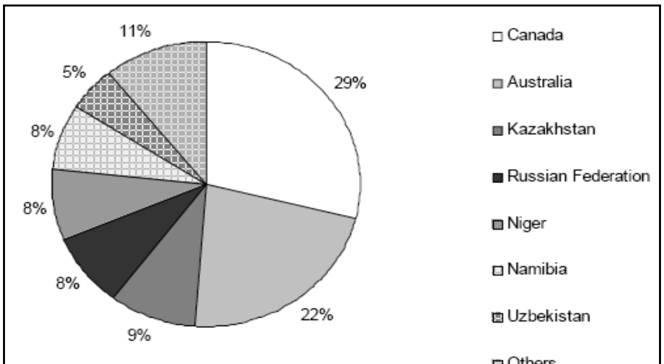
The uranium resources are more or less evenly distributed in the five continents. Australia has the highest reserves followed by Kazakhstan and Canada.However, Canada has some of the highest grades (~20%) uranium ores and is the highest producer of uranium. Canada and Australia together account for more than 50% of the world's uranium production

The total estimated known **"identified"**(discovered) **conventional** uranium resources, which can be mined for <US $130/kg, more or less matching the current spot price, is 4.74 million tonnes. More than 50% of these reserves are in countries like Australia, Kazakhsatn, Namibia, Niger, Uzbekistan, which do not have any nuclear power programme. The uranium produced in these countries is mostly consumed in Member States having no uranium resources or production facilities.

Undiscovered Conventional resources include **"prognosticated"** resource and **"speculative"** resources. Under these categories, an estimated quantity of 7.70 million tonnes recoverable at <US $130/kg U is available. Further, another 2.98 million tonnes are available under the **"speculative"** category with mining cost unassigned. Uranium resources classified as **"unconventional"**, in which uranium exists at very low grades or can only be recovered as a minor by-product, include some 22 million tonnes that occur in phosphate deposit, where uranium can be produced at a price range of US $60-100/kg U as by-product of phosphoric acid production.

The world annual production of uranium for the year 2004 was 40 263 t U, which provided about 60% of the world reactor annual requirements of some 67 000 tonnes. The remainder of the uranium demand was met by secondary sources including excess commercial inventories, down-blending of highly enriched uranium (HEU) warheads to lowly enriched uranium (LEU: <20% U-235 but in currently operating LWR U-235 enrichment is $\leq$5%), re-enrichment of depleted uranium tails and Reprocessed Uranium (RepU) and plutonium substitution in the form of mixed uranium plutonium oxide fuel.

Historically, uranium production has principally involved open-pit and underground mining. However, over the past two decades, in-situ leach (ISL) mining, which uses either acid or alkaline solutions to extract the uranium directly from the deposit, has become increasingly popular. In the year 2004, underground mining accounted for 39% of the global uranium production followed by open-pit mining 28% and ISL 20%. ISL is the main method of uranium extraction in Kazakhstan and Uzbekistan. ISL has extensively been used in the Russian Federation and the USA and has recently been introduced in Australia.



Uranium Production in 2004: 40 263 tU

Worldwide uranium exploration expenditure in 2004 totalled over US $130 million, an increase of almost 40% compared to 2002 and close to US $200 million in 2005. This is expected to lead to further additions to the uranium resource base, just as periods of heightened exploration efforts in the past have done. A significant number of new uranium mines and mills are likely to be opened and expansion of existing facilities are foreseen in the next few years in Australia, Brazil, Canada, China, India, Islamic Republic of Iran, Kazakhstan, Namibia, Niger, Russian Federation. This would significantly boost the world uranium production capacity.

By 2025, world nuclear energy capacity is expected to grow to between 450 GW(e) and 530 GW(e) from the present level of ~370 GW(e). This will raise annual uranium requirements to between 80 000 tonnes and 100 000 tonnes. The currently "identified" resources are adequate to meet this expansion even in 'once-through' open fuel cycle, which utilizes only some 1% of the energy potential of natural uranium. In the longer term, continuing advances in nuclear technology will allow substantially better utilization of uranium resources. The spent uranium fuels from the operating reactors contain some 96% of uranium, 3% of fission products and 1% of plutonium and minor actinides (MA). The plutonium and MA could be subjected to multiple recycling, in combination with uranium, in fast breeder reactors, which breeds more plutonium than it consumes, thereby, utilizing the energy potential locked in natural uranium by a factor between 30 to 70 depending on the efficiency of the fast reactor and closed fuel cycle technologies.

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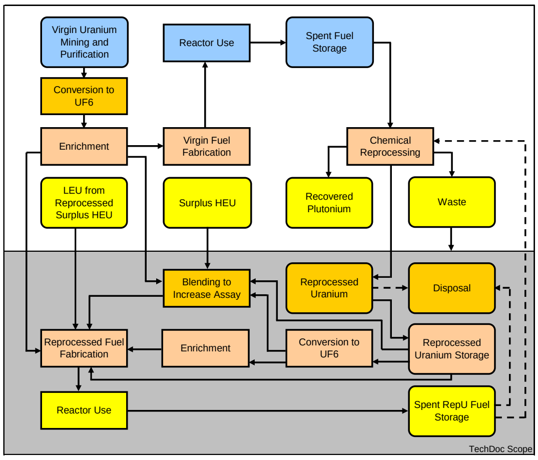
Management of Reprocessed Uranium

The issue of recycle of valuable material is important for the nuclear fuel cycle in the context of sustainable growth of the nuclear energy. As major fraction of spent fuel is made-up of uranium, chemical reprocessing of spent fuel would leave behind large quantities of separated uranium which is called as "reprocessed uranium" (RepU). In some countries (such as France, India, Japan, Russian Federation, etc.) reprocessing of spent fuel has been viewed as a viable fuel cycle option. Some countries hold reprocessed uranium as the result of their commercial reprocessing service contracts for reprocessing of spent fuel with others. In some of these countries, the use of RepU is already taking place. Recognizing the importance of this subject, the Agency has formed a working-group to review and summarize the information on the management of reprocessed uranium and the report is in advanced stage of publication. The scope of this working group is restricted to the lower portion of the scheme described in the following figure.



The working-group reviewed several issues in management of reprocessed uranium such as RepU arisings, storage, chemical conversion, re-enrichment, fuel fabrication, transport, reactor irradiation, subsequent reprocessing and disposal options. The salient findings of the working group are given below. The recycling of RepU is an established process through proven technologies which has been taking place since the 1970s. The technical and radiological problems associated with the handling of RepU by fuel fabricators and those loading fuel into reactors are manageable, but they require a certain minimum volume throughput to justify the investment required to minimise dose uptake by fabrication plant operators. The fuel design and reactor licensing issues are also readily manageable and are generally less than the political and public relations issues associated with deciding to load RepU into a reactor.

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Technical Workshop and International Symposium on Minimisation of Highly Enriched Uranium in the Civilian Nuclear Sector, Oslo, Norway 17-20 June 2006

The Norwegian Government has become increasingly active in supporting the minimization and elimination of HEU in civil nuclear applications. In connection with these activities two meetings (a workshop and a symposium) were formulated by the Norwegian Government to support its objectives regarding HEU minimization. The Norwegian Government sought IAEA support for the organization of the meetings in late fall 2005.

The two meetings were designed to be mutually supporting. The Technical Workshop was to review and discuss technical issues related HEU minimization, with a hoped-for consensus on the technical feasibility of eliminating HEU from civil uses. This result was then to be communicated to the International Symposium, whose objective was to formulate concrete policy options for advancing the goal of HEU minimization. Approximately 100 participants from thirty-nine countries attended the two meetings which took place over four days. About a dozen ambassadors/Board Governors attended the policy-oriented sessions of the Symposium.

Results of the meeting

The Technical Workshop achieved a broad consensus that virtually all research reactors can use LEU fuel without a significant penalty to their educational, scientific, technical, and industrial applications. Several presentations made by reactors that have already converted to LEU clearly demonstrated that any "flux penalty" that resulted from the conversion can be managed and compensated by other measures so as not to affect the performance of the reactor. It was also concluded that:

- approximately 42 research reactors can convert at present using currently qualified and available LEU fuels;
- when very high-density LEU fuel is qualified and commercially available – projected to be around 2011/12 – most of the high-power research reactors will be able to be converted; and
- new state of the art, multi-purpose research reactors can be designed to operate on LEU fuel. In connection with research and development efforts for future advanced power reactors and fuel cycles, it was agreed that HEU would not be needed as fuel for such reactors.

There was broad consensus that the production of Mo-99 from LEU is technically feasible, and that future new producers of Mo-99 should do so from LEU only. There was also consensus that the only significant obstacles to conversion to LEU of the present major Mo-99 production facilities are economic, financial, and political.

It was agreed that the reduced enrichment for research and test reactor (RERTR) programme and the related research reactor spent fuel "take-back" programmes have made significant progress in HEU minimization, and that there is substantial and successful international collaboration in this area. The workshop called for these efforts to be enhanced and expanded on the basis of voluntary decisions by states interested in converting reactors or returning spent fuel to the country of origin. The positive role of the IAEA in these efforts was highlighted, and there was broad consensus that the IAEA should expand its relevant activities, including promoting cooperation between and international sharing of research reactor facilities.

The International Symposium was marked by broad political discussions placing this subject within the context of the global nuclear disarmament debate, especially regarding the differing obligations of nuclear weapons states and non-nuclear weapons states under the Nuclear Non-Proliferation Treaty (NPT).

A number of representatives stressed that actions to minimize HEU should not impinge upon the rights to develop peaceful uses of nuclear energy under Article IV of the NPT.

However, there was consensus that activities related to the minimization of HEU in the civil sector should proceed on the basis of voluntary requests by national authorities, in the context of available donor funding and international technical assistance.

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Coordinated Research Projects (CRP)

CRP on Optimisation of Water Chemistry to Ensure Reliable Water Reactor Fuel Performance at High Burnup and in Aging Plant (FUWAC)

Corrosion of fuel rod cladding and primary circuit component materials has for many years remained a serious concern for water cooled nuclear power reactors, especially those operated at high burnup and thermal ratings. In response, the IAEA has run a series of Co-ordinated Research Projects aimed at better understanding of the cladding corrosion processes (CCI, 1981-86), water coolant technology improvement (WACOLIN, 1987-91), development and implementation of advanced on-line water chemistry and corrosion monitoring techniques/sensors in nuclear power plants (WACOL, 1995-2000) and development and implementation of data processing technologies for water chemistry and corrosion control" (DAWAC, 2001-2005).

The new CRP, FUWAC, held its first Research Coordination Meeting in July 2006 in Vienna and the members agreed that the work should focus on monitoring, maintaining and optimising water chemistry regimes in primary circuits of water cooled power reactors, taking into account high burnup operation, mixed cores and plant aging, including following issues and remedies:

- Understanding the causes and mechanisms of crud deposition on fuel and its composition, which can cause crud induced power shifts (CIPS) or localised clad corrosion for high burnups and also for advanced water chemistry regimes (noble metals or zinc addition, etc.) and "old" units;
- Materials behaviour at high burnup, also for "old" units, including
  – Fuel rod claddings;
  – Other materials (inconel, stainless steel);
- Dosimetry.

Remedies by chemistry optimisation for high burnup, mixed cores, plant ageing:

- Concentration and type of alkaline reagent;
- Hydrogen concentration and production mode (direct injection or through NH_3);
- Fuel cleaning (chemical cleaning, ultrasonic cleaning);
- Decontamination and post-decontamination water chemistry treatment;
- Use of enriched boric acid (EBA) in ^{10}B.

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CRP on Spent Fuel Performance Assessment and Research (SPAR II)

Spent fuel storage technology (particularly dry storage) is undergoing evolution, with modified/new fuel and material designs and increasing target burnup levels. Increased burnup infers higher strains and increased cladding hydriding and oxidation. The Co-ordinated Research Project on spent fuel performance assessment and research (SPAR) addressed research needed to justify spent fuel storage for very long periods of time (more than fifty years). Building on the three earlier BEFAST projects (Behaviour of spent fuel and storage components during long term storage) documented in IAEA-TECDOCs-414, 673, and 944, SPAR efforts began in 1997 with eleven participating countries, and resulted in a technical document published in 2003 [TECDOC-1343]. Building on the results of the BEFAST and SPAR coordinated research projects, a subsequent coordinated research project (SPAR-II) was approved in 2004 for implementation through 2008. SPAR-II research objectives include surveillance and monitoring programmes for spent fuel storage facilities, fuel materials performance evaluation for wet/dry storage, and collection and exchange of spent fuel storage experience. Participants include representatives from Canada, France, Germany, Hungary, Japan (two institutions), Republic of Korea, Slovakia, Spain, the USA, and the European Commission. Sweden attends with observer status and participants from the UK and possibly from the Russian Federation are expected to join the CRP. Initial draft text for the SPAR-II technical document is being developed, based on results from the June 2005 research coordination meeting in Karlsruhe, the November 2005 consultancy in Erlangen, and the pending November 2006 research coordination meeting in Tokyo.

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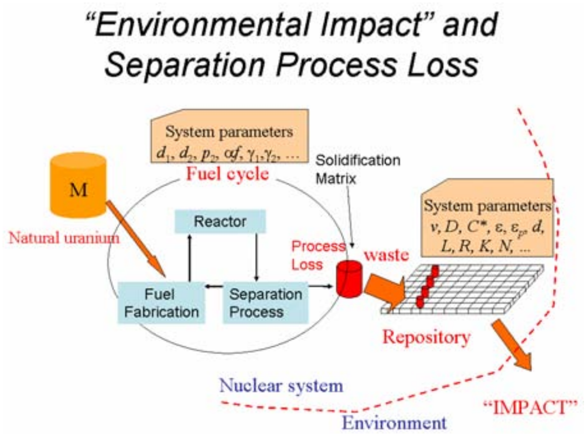
CRP on Study of Process-losses in Separation Processes in Partitioning and Transmutation Systems in View of Minimizing Long Term Environmental Impacts

Partitioning and transmutation (P&T) of spent nuclear fuels has the potential to reduce volume, radiotoxicity and decay heat of high level waste , thereby reducing radiological risk from a few millions years to few hundreds of years and minimising the repository space requirements. In addition, P&T will also facilitate effective utilization of natural uranium resources P&T involves a series of chemical, metallurgical and nuclear operations by which all the actinides (Pu, Am, Cm, Np) and some selected fission products (99Tc, 129I, etc.) are separated from the discharged spent fuel and recycled as fuels/targets. Minimization and precise evaluation of minor actinide elements in the waste from the separation process can contribute considerably to an improved protection of the environment. In this context this CRP is initiated with an aim to understand the environmental impact considering losses in the P&T steps. The objectives of this CRP is to enable Member States in developing methodologies for reducing radiotoxic discharge to environment from nuclear fuel cycle activities and pave the way for sustainability of nuclear energy.



The following institutes from Member States have joined this CRP: 1) CIAE, China; 2) NRI, Czech Republic; 3) ITU, Germany; 4) IGCAR, India; 5) CRIEPI, Japan; 6) KAERI, Republic of Korea; 7) RIAR, Russian Federation; and 8) Univ. of California, USA. The following subjects-areas of research were examined upon in the three RCMs held so far.

- Basic studies to compare dry partitioning process with aqueous partitioning process;
- Defining proliferation resistance attributes of partitioning processes;
- Advanced characterization methods for actinides for measuring the possible material hold-up;
- Minimization of actinides losses in the waste fraction from the partitioning process;
- Establishment of separation criteria of partitioning process to minimize environmental impact;
- Defining environmental impact associated with partitioning processes.

The salient outcomes of this CRP were: 1) A definition of sources of possible losses of long-lived radiotoxicity and their chemical form of waste from pyrochemical processing; 2) an explanation of target value for the reduction of ratio of radiotoxicity in line with current process losses from pyro-chemical processing; 3) a quantitative relationship between environmental impact and waste reduction ratio considering separation losses is established. And elaboration of the P&T factors listed above in minimization environmental impact by a comprehensive model is being addressed.

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CRP on Developing Techniques for Small-scale Indigenous Production of Mo-99 using LEU Fission or Neutron Activation

Background

Technetium 99m, the daughter product of Molybdenum 99 (Mo-99), is the most commonly utilized medical radioisotope in the world. Annually, it is used for approximately 20-25 million medical diagnostic procedures, alone comprising some 80% of all nuclear medicine procedures. Today, most Mo-99 is produced in research, test or isotope production reactors by irradiation of Highly Enriched Uranium (HEU) targets that are subsequently processed primarily to recover Mo-99. There are only a few major commercial pro-ducers of Mo-99, all of them utilizing HEU targets and dedicated processing facilities. However, in line with RERTR, and the objective of minimizing and eventually eliminating the use of HEU in civil commerce, international efforts are underway to shift the production of medical isotopes away from the use of HEU.

Some developing Member States are seeking to become small scale, indigenous producers of Mo-99 to meet local nuclear medicine requirements. Such production is potentially attractive in order to further develop domestic nuclear technology capabilities, take advantage of relevant nuclear facilities and expertise, reduce dependence on foreign supply, and save hard currency expenditures. In order to pursue such production, countries need access to LEU fission target technology or alternative means to produce Mo-99, as HEU is no longer freely available. Thus, the objective of the IAEA Coordinated Research Project (CRP) is to provide support for small-scale local production of Mo-99 for Tc-99m generators by fostering the use of LEU targets for fission product Mo-99 and to foster the development of alternative technologies.

The objectives of the CRP are to:

- Assist member states with the development, transfer, and adaptation of LEU-based technology and neutron activation methods;
- Demonstrate technical efficacy of LEU and neutron activation production of Mo-99;
- Foster capacity building for local/regional self-sufficiency to meet Mo-99 needs;
- Advance international non-proliferation and nuclear security objectives, while promoting sustainable development and the sustainability of nuclear research institutes.

Six institutions in four countries have been awarded research contracts:

- Chile: LEU fission foil targets;
- Kazakhstan: gel generators;
- Libyan Arab Jamahiriya: LEU fission foil targets;
- Pakistan: LEU fission foil targets;
- Romania1: gel generators;
- Romania2: LEU fission foil targets.

Five institutions in five countries have been awarded research agreements:

- Argentina: LEU mini-plates;
- Republic of Korea: development of LEU foil targets;
- India: standardization of gel generators and feasibility of fission moly;
- Indonesia: development of LEU foil targets;
- USA: LEU-modified Cintichem foil targets.

The project has a four-year time frame (2005-2009).

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CRP on Corrosion of Aluminium-clad Research Reactor Fuel in Water

A large variety of spent fuel with different fuel meats, different geometries and different enrichments in 235U are presently stored underwater in basins located around the world. More than 90% of these fuels are clad in aluminium or aluminium based alloys that are notoriously susceptible to corrosion in water of less than optimum quality. Some fuel is stored in the reactor pools themselves, some in auxiliary pools (or basins) close to the reactor and some stored at away-from-reactor pools. Corrosion induced degradation of the fuel cladding has been observed in many of the pools.

General corrosion of aluminium and its alloys is reasonably well understood and is not a problem with degradation of RR fuel. It is the much more insidious problem of localized corrosion which has led to serious safety issues at several RR spent fuel pools. The three main forms of localized corrosion are pitting corrosion, crevice corrosion and galvanic corrosion. The localized corrosion of aluminium-clad spent fuels is an extremely complex phenomenon and difficult to predict.

Some important findings of this CRP are the influence of sediments and coupon orientation in corrosion mechanisms. It has been also made evident that water quality affects crevice and galvanic corrosion and that sediments produce degradation independently of water quality. These findings are a consequence of the research performed within the CRP and will result in a significant improvement of the measures applied to properly maintain wet storage facilities for aluminium cladding fuel.

Operator handling test coupons

Test coupons from a spent fuel pool with poor water quality

This CRP has demonstrated the importance that all countries handling aluminium clad spent fuel in water basins, should set up their own corrosion surveillance-monitoring and water quality programmes. These activities should comply with many requirements that have been established during the CRP.

The CRP was concluded following the final Research Coordination Meeting held at the IAEA headquarters in Vienna in December 2005. A Technical Report summarizing the results of the CRP is expected to be complete in 2007.

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CRP on Conversion of Miniature Neutron Source Research Reactors (MNSR) to Low Enriched Uranium (LEU)

The Chinese-built Miniature Neutron Source (MNSR, 27 kW) reactors (four in China, and one each in Ghana, Islamic Republic of Iran, Pakistan, Syrian Arab Republic and Nigeria) are low-power, neutron source research reactors used primarily for neutron activation analysis, education, and training. These reactors have cores consisting of less than 1 kilogram of HEU, enriched to 90% or greater, U-235.

Since 1978, various national and international activities have been underway to convert research and test reactors from the use of HEU to LEU fuel. These activities support the objective of reducing and eventually eliminating the civil use of HEU. Achieving the conversion of all MNSR reactors would be a helpful step forward in this international effort to reduce and eventually eliminate the civil use of HEU.

The China Institute of Atomic Energy (CIAE) has designed a new MNSR using LEU to operate in hospitals. It has also has been studying conversion of the existing MNSR cores to LEU. China has also designed and built, with commissioning expected in 2006, a large 60 MW research reactor that will use LEU fuel.

At a Technical Meeting at IAEA Headquarters in May 2005, all the participating MNSR operators indicated their desire to convert to LEU fuel. It was acknowledged that to successfully carry out MNSR core conversions, a number of preparatory steps, including additional analysis and various calculations have to be made, in order to confirm the feasibility of conversion. These activities will be carried out under a new CRP that will involve the CIAE, as designer of the MNSR reactors, and institutions in five other countries which currently operate MNSRs, with the goal of producing all the necessary technical preparations and documentation to provide guidelines for the successful conversion of the MNSRs to LEU.

The overall objective is to assist institutions in Member States with MNSR reactors with HEU cores to convert to LEU fuel with minimal reduction of the utilization capacity of the reactors in concert with international non-proliferation initiatives to reduce and eventually eliminate the use of HEU in civil commerce. Extra budgetary funding is to be provided to cover all activities of the CRP for its duration (2006-2009) from the RERTR-DOE.

The CRP was approved in June 2006 following the receipt of a letter from China supporting the involvement of the China Institute of Atomic Energy (CIAE) for work on fuel MNSR conversion and related activities. In this letter information from previous MNSR supply agreements was reiterated; that spent fuel from Ghana, Nigeria and Syrian Arab Republic would be returned to China.

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Recent Publications

Technical Reports Series No. 435
Implications of Partitioning and Transmutation in Radioactive Waste Management (2005)

Technical Reports Series No. 436
Disposal Options for Disused Radioactive Sources (2005)

Technical Reports Series No. 439
Decommissioning of Underground Structures, Systems and Components (2006)

Technical Reports Series No. 441
Management of Problematic Waste and Material Generated During the Decommissioning of Nuclear Facilities (2006)

Technical Reports Series No. 442
Remediation of Sites with Mixed Contamination of Radioactive and Other Hazardous Substances (2006)

Technical Reports Series No. 443
Understanding and Managing Ageing of Materials in Spent Fuel Storage Facilities (2006)

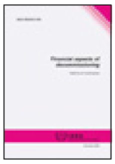
Technical Reports Series No. 444
Redevelopment of Nuclear Facilities after Decommissioning (2006)

Technical Reports Series No. 445
Applicability of Monitored Natural Attenuation at Radioactively Contaminated Sites (2006)

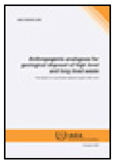
Technical Reports Series No. 446
Decommissioning of Research Reactors: Evolution, State of the Art, Open Issues (2006)

IAEA-TECDOC-1463
Recent Developments in Uranium Exploration, Production and Environmental Issues (2005)

IAEA-TECDOC-1467
Status and Trends in Spent Fuel Reprocessing (2005)



IAEA-TECDOC-1476
Financial Aspects of Decommissioning (2005)



IAEA-TECDOC-1481
Anthropogenic Analogues for Geological Disposal of High Level and Long Lived Waste (2006)

IAEA-TECDOC-1482
Technical, Economic and Institutional Aspects of Regional Spent Fuel Storage Facilities (2005)

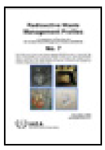
IAEA-TECDOC-1492
Improvements of Radioactive Waste Management at WWER Nuclear Power Plants (2006)

IAEA-TECDOC-1504
Innovative waste treatment and conditioning technologies at nuclear power plants (2006)

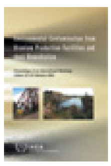
IAEA-TECDOC-1508
Spent fuel management options for research reactors in Latin America (2006)

IAEA-WMRA-30
Waste Management Research Abstracts, Volume 30 (2005)

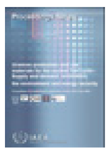
RWM Status and Trends
Radioactive Waste Management – Status and Trends, Report No. 4 (2005)



Radioactive Waste Managem. Profiles No. 7
A Compilation of Data from the Net Enabled Waste Management Database (NEWMDB) (2005)



STI/PUB/1228
Environmental Contamination from Uranium Production Facilities and their Remediation Proceedings of an International Workshop, Lisbon, Portugal, February 2004 (2005)



STI/PUB/1259
Uranium Production and Raw Materials for the Nuclear Fuel Cycle - Supply and Demand, Economics, the Environment and Energy Security (2006)

Meetings in 2006

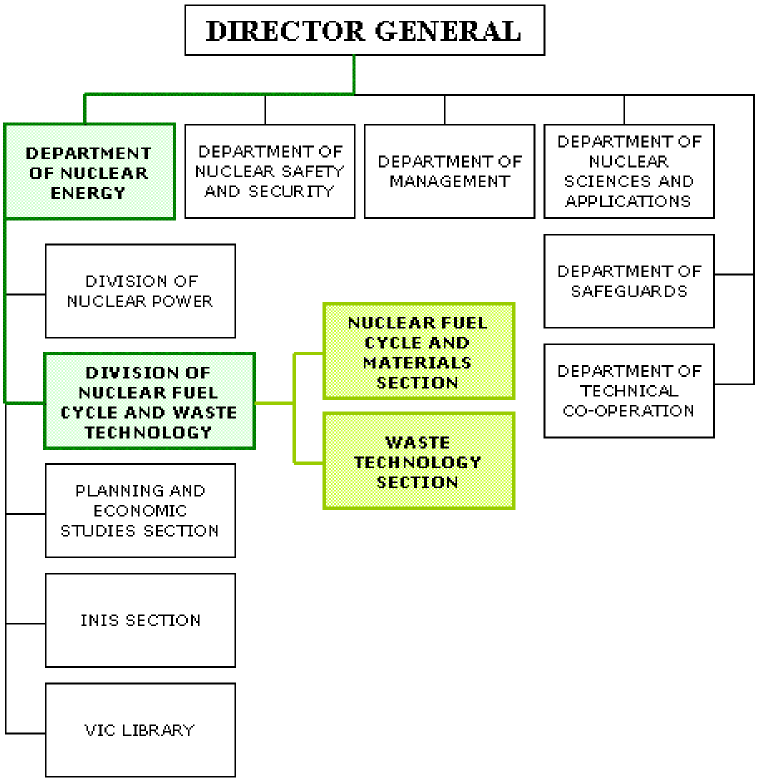
Date	Title	Place	Contact
28-31 August	Technical Meeting on National Experiences on Return of Research Reactor Spent Fuel to the Country of Origin	Vienna, Austria	I.Goldman@iaea.org
28 Aug. - 1 Sep.	Technical Meeting on In-Situ Leaching of Uranium Deposits	Almaty, Kazakhstan	J.Slezak@iaea.org
4-8 September	Technical Meeting on Experience in Managing Disused Sealed Radioactive Sources	Vienna, Austria	J.Balla@iaea.org
25-27 September	Training Meeting/Workshop on Planning and Design of Geological Repositories	Vienna, Austria	B.Neerdael@iaea.org
26-28 September	Technical Meeting on High Burnup Fuel Experience and Economics	Sofia, Bulgaria	J.Killeen@iaea.org
9-11 October	Training Meeting/Workshop on Modernization and Refurbishment of Research Reactors	Delft, Netherlands	E.Bradley@iaea.org
9-13 October	Technical Meeting on Uranium Exploration, Mining, Production and Mine Remediation and Environmental Issues	Mendoza, Argentina	J.Slezak@iaea.org
30 Oct. – 1 Nov.	Technical Meeting on Lessons Learned by Member States in Operating Low Level Waste Processing and Storage Facilities	Vienna, Austria	A.Kahraman@iaea.org
30 Oct. – 2 Nov.	Training Meeting/Workshop on LEU Fuel Utilization in ADS System	Vienna, Austria	P.Adelfang@iaea.org A.J.Soares@iaea.org
31 Oct. – 2 Nov.	Technical Meeting/Workshop on Technical Conditions for Radioactive Waste Long Term Storage	Vienna, Austria	J.Kelly@iaea.org
6-10 November	Research Coordination Meeting on Spent Fuel Performance Assessment and Research (SPAR-II)	Tokyo, Japan	W.Danker@iaea.org
20-22 November	Technical Meeting on Research Reactor Support Needed for Innovative Nuclear Power Reactors and Fuel Cycles	Vienna, Austria	E.Bradley@iaea.org
20-24 November	Training Meeting/Workshop on the Role of Partitioning and Transmutation in Mitigating the Potential Environmental Impacts of Nuclear Fuel Cycle	ICTP Italy	H.Nawada@iaea.org C.Ganguly@iaea.org
27-30 November	Technical Meeting on Hot Cell Post Irradiation Examination Techniques and Poolside Inspection of Water Reactor Fuel Assemblies	Buenos Aires, Argentina	V.Inozemtsev@iaea.org
27 Nov. – 1 Dec.	Training Meeting/Workshop on Safety, Regulatory, Security Environmental and Waste Management Aspects of Mo-99 Production	Petten, NL, Fleures, BEL	P.Adelfang@iaea.org I.Goldman@iaea.org
4-6 December	Training Meeting/Workshop on the Net-Enabled Waste Management Database (NEWMDB)	Vienna, Austria	J.Kinker@iaea.org
5-8 December	Technical Meeting on Pressurized Heavy Water Reactor (PHWR) Fuel Modelling	Mumbai, India	J.Killeen@iaea.org
11-15 December	International Conference on Lessons Learned from Decommissioning of Nuclear Facilities and the Safe Termination of Nuclear Activities	Athens, Greece	M.Laraia@iaea.org

IAEA International Conference on Lessons Learned from the Decommissioning of Nuclear Facilities and the Safe Termination of Nuclear Activities

11-15 December 2006 Athens, Greece

- Based on progress achieved, the time is ripe for an extensive information exchange among decision makers, regulators, radiation and waste safety specialists, and the nuclear industry on lessons that have been learned during the planning and implementation of past decommissioning projects. The lessons learned from one organization can have a significant beneficial impact on organizations starting the decommissioning process for the first time, especially for Member States with limited nuclear programmes.
- The Conference is structured in 8 sessions (Global Overview; Regulation of Decommissioning Activities; Planning for Decommissioning; Implementation of Decommissioning Activities; Waste Management Issues; Technology Aspects; Social and Economic Impacts; Decommissioning of Small Facilities) including also panel discussions. There is also a poster session for contributed papers and a technical exhibition.
- Held in co-operation with OECD/NEA, EC and WNA. IAEA Scientific Secretaries are B. Batandjieva (NS) and M. Laraia (NE) with K. Morrison (MT) as administrative point of contact.
- The preliminary conference programme and related information are available at http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=143
- The previous decommissioning conference was held in October 2002 and attended by some 300 participants from 40 countries and international organizations. Proceedings are available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1154_web.pdf

Division of Nuclear Fuel Cycle and Waste Technology WebSite Links
Division Introduction NEFW home: http://www.iaea.org/OurWork/ST/NE/NEFW/index.html



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
- Databases (NFCIS, UDEPO, VISTA, PIE)
  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

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